ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

VOL. LVI. No. 5. 220 Broadway, New York, August 2, 1906.

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THE CONSTRUCTION OF MOUNTAIN PASS ROADS IN CAPE COLONY, SOUTH AFRICA.

By R. Bromley.*

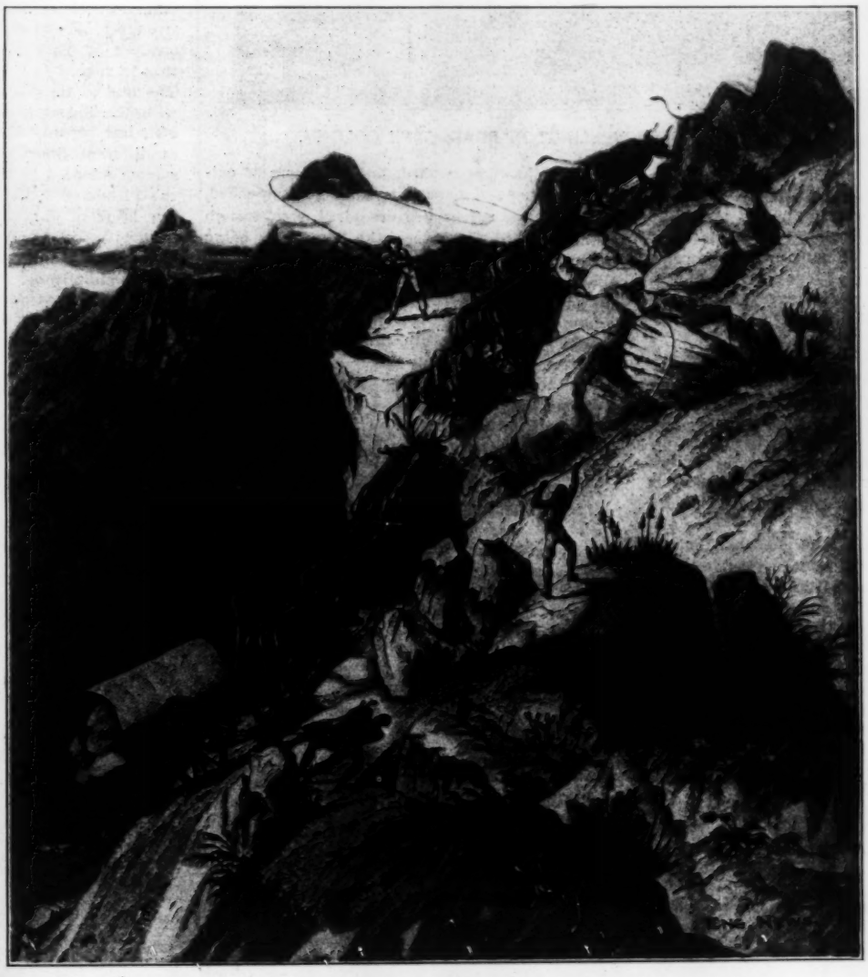
The coast districts in Cape Colony are cut off from communication with the interior by parallel mountain ranges. These form successive terraces, as it were, with a considerable rise on the sea side and comparatively little fall on the interior slopes.

Originally the interior slopes were impassable to traffic except at certain few points consisting either of deep, rocky gorges through which a mountain torrent flows, conveying the drainage from the interior to the sea, or of low gaps, or "necks," of from 1,500 to 5,000 ft. in height. These occasional breaks in the gigantic rock barriers of this country present a comparatively easy passage over green, rocky slopes at grades of 1 to 3 or less.

The early settlers found means of crossing the mountains by one or other of the above-mentioned ways; although, to look at these routes now-a-days, it would seem incredible that any sane persons should attempt such a feat with a heavy wagon. It was done, however, in numerous instances, as some of the old tracks still remain to prove. In places where the rocks were fairly soft the wheel marks of the old tracks are still visible; so are they also at boulder beds from which the larger boulders were thrown in order to clear the way.

In the old days a grade of 1 in 3 was common. In such passes as French Hoek Pass, Paarl, Cradock Pass, George, Meiring's Poort, Oudtshoorn, and many others, the wagons generally traveled in trains, so that the several wagons could assist one another. Instances are still recalled when, several times in the course of a journey, wagons had to be taken to pieces and hauled up or let down by ropes and pulleys over almost perpendicular slopes—a proceeding which must have taken days. Then the loads were pulled up, the wagons reloaded, and the ever-patient oxen inspanned and slowly moved on to the next obstacle, until finally the plain was reached again.

The accompanying illustration, drawn and engraved by C. C. Mitchell, representing Cradock Pass in 1840, will afford a lively idea of the condition of the old Boer passes. Often 60 oxen or even more were inspanned to one wagon to pull it up a slope.



THE ASCENT OF CRADOCK PASS, CAPE COLONY, SOUTH AFRICA, IN 1840.

In modern times the nearest approach to this sort of work was the conveyance of the heavy mining machinery from the then terminus of our railway line at Kimberley to Johannesburg. In one instance, the boiler for the Simmer and Jack mine, weighing 22,000 lbs., was conveyed all the way on a wagon, six spans of 20 oxen each being inspanned in front of it to pull the load through the boggy ground of some localities. The conveyance of this load cost £450 and occupied 30 days.

In constructing these old mountain pass roads either over the mountains or through the gorge along the rivers, the old pioneers had to do all the work with the pick, shovel and bar alone, as explosives were then almost unknown, and certainly were never used on any of these tracks.

It was some 70 years ago that properly constructed mountain pass roads to replace these old Boer tracks were commenced under the direction of the late Col. Mitchell, one time Colonial Engineer and Surveyor General of the Colony, and A. G. Bain, R. E. Many very fine roads were then constructed, which will bear comparison with any like undertaking in other parts of the world. In late years other mountain pass roads have been constructed under the supervision of A. G. de Smidt, C. E., the late T. C. Bain, M. Inst. C. E., and, *inter alios*, the author.

Many of these routes have now fallen into disuse, owing to advancing railway construction, and others have been improved. In the old days, however, they served their purpose in saving many days' traveling with wagons in long detours. Two modern passes are shown in the accompanying illustrations.

MODERN METHOD OF MOUNTAIN PASS ROAD CONSTRUCTION.

In the construction of mountain pass roads in Cape Colony at the present day, the route is first inspected on foot or horseback, as the case may be (in some instances the country was so rough that it was difficult to do this even on foot). Certain fixed points for crossing ravines (or "kloofs," as they are called here), avoiding precipices, crossing ridges, etc., are determined, and the best grades obtainable between these fixed points are set out with a clinometer with movable arm, set to a certain grade. Pegs are then driven 20 ft. apart, giving the formation level

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BAIN'S KLOOF PASS, WORCESTER- WELLINGTON ROAD, CAPE COLONY.

over all rough ground; the intersection of the ground or rock with the pin is the level of the road (not necessarily the center line). A bridle path on the formation level of the road is then made 3 ft. wide, scraped or built up, as the case may be, from pin to pin. Thus is formed a miniature road, providing, as is very necessary, a means of easy communication with the work as it proceeds.

The widths of permanent roads are now set out with batter of retaining walls or banks, as the case may be, and the construction of the permanent road commences.

RETAINING WALLS.—As derived from practical experience, the best batter for retaining walls is 1 in 6. They must be built on a solid foundation, and wherever possible on solid rock, benched for the purpose.

The foundation need not be wider than is required to take the bottom or foot stones; but the rock should be again benched as the work progresses—two or three times, according to the height of the wall. Above all, care should be taken to remove, from either single or double retaining walls, any other substance than clean, hard rock from bottom to top. Surfacing mortar is not used in building any part.

The building stone for walls is merely hammer-dressed on the site, as it is put in position by the masons. Only the face of the wall is actually built, but the backing stones are carefully packed and fitted into position behind, forming a solid and immovable mass of clean stone, which no amount of percolation of water will move.

The retaining walls are all built alike as to their section and the character of material, but vary from 1 to 60 ft. in height. The latter is, however, an exceptional height; 10 ft. to 30 ft. is the most common. These walls look very well, when well built in the manner described and finished off with spawls. The author has never known them either to bulge, slip, fall or move in any way. All sorts of modifications are tried by amateur engineers, none of which however, are satisfactory or stand long. This, perhaps, is owing to one of three causes, viz.: bad foundation, the use of bad material for backing, or the use of stone for building that will not weather well.

CULVERTS.—Culverts are limited only to the size of covering stone obtainable, say from 2 to 10 ft. in height or width, although in the latter size stone of sufficient length for covers is rarely obtainable. In some cases two stones meeting in the center have been used, but this form of culvert cannot, as a general rule, be recommended.

When larger culverts are required, steel trough decking is used for covers, the abutments being carried up to the level of the underside of the ballast of roadway.

To prevent debris lodging in the culverts and to facilitate clearing, they should always have a straight run. In all cases where the bottom is not of hard rock, they must, to prevent scour, be floored with flat stones. Entrances to culverts may be excavated outside the width of the road. Considerable provision in the way of catchwater drains, culverts, etc., has to be made to meet the periodic torrential downpours in these mountains.

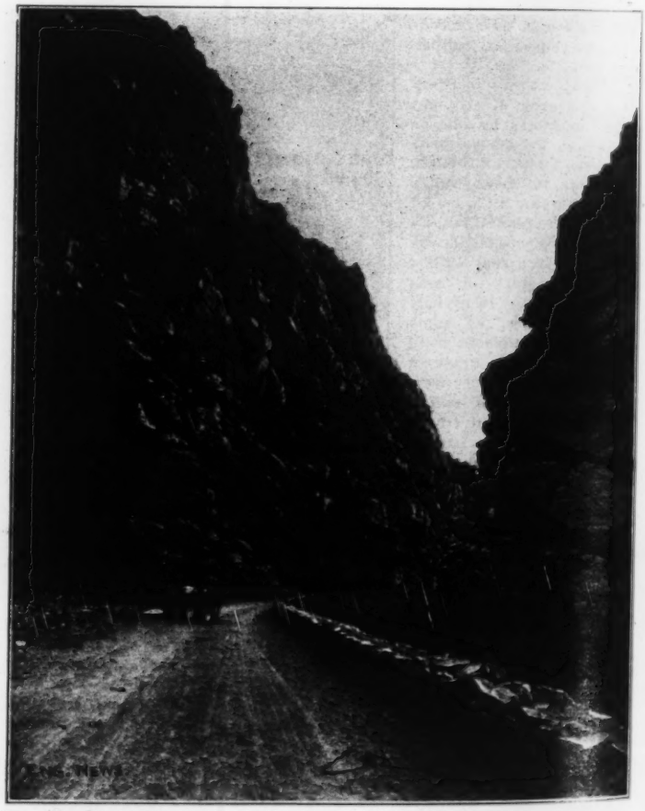
Grades of finished roadway for all first-class roads are usually limited nowadays to 1 in 15. There are, however, many steeper, even down to 1 in 7; but the latter are not usually found on roads of recent construction, and many have been constructed in place of very steep old tracks over mountains where even the grades 1 in 7 now appear quite easy in comparison to those of the old days.

WIDTH OF PASSES.—The usual limit of the width of passes is 18 ft. In very expensive work, such as a rock cutting of 50 ft. depth, less is sometimes taken for short lengths. A width of 18 ft. is, however, just sufficient space for two vehicles to pass each other in safety.

As provision has to be made for wagons carrying up to 10,000 lbs., drawn by spans of [illegible] or ten pairs of oxen, or donkeys, curves should accordingly be not less than 50 ft. radius on the concave side, and then should always be constructed on the level, to enable the wheel animals to draw the load.

CARD-INDEX RECORD AND FILING SYSTEMS FOR ENGINEERS AND CONTRACTORS.

The remarkable development of the card-index system of keeping and filing records has afforded exceptional facilities for simplifying the important records employed by engineers and contractors, and for making these records more easily available than under any other system. This applies especially to the records of progress and cost of works under construction, in which it is of great importance to keep constant track of these two features. With a number of such works in hand it would be difficult to keep them under constant supervision and control from the office by any but a card-index system, which enables the figures for all or any one of the works to be made readily accessible. The system is also now being largely used in keeping individual ledger accounts and other office records, and it is stated that the adaptation of the card system to bookkeeping purposes has been one of the strongest aids in simplifying and facilitating the conduct of office affairs. This is especially the case in regard to construction and contract work. The use of the card-index system in connection with the indexing and filing of plans, drawings, etc., has already been described in our columns at different times, and a full description of the system adopted in the engineering department of the Pittsburg & Lake Erie Ry. was published in our issue of Jan. 2, 1902. As examples of the various records and other purposes to which the card-index system is adapted, we present herewith a number of representative cards in actual use by different companies and firms. Most of these are made by the Yawman & Erbe Mfg. Co.,



ZWARTBERG PASS, PRINCE ALBERT OUDTSHORN ROAD, CAPE COLONY, SOUTH AFRICA, 1906.

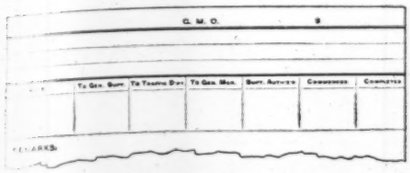


Fig. 1. Card Record of New Work; Southern Pacific Ry.

of Rochester, N. Y., and for copies of them, with general particulars of their use, we are indebted to Mr. Wm. J. Mullin, Manager of that company's educational department, and to Mr. Myron S. Falk, Engineer of the Godwin Construction Co., New York.

In regard to the introduction of these systems Mr. Mullin states as follows:

Engineers of all classes have been quick to respond to the advantages gained by having an efficient record system in their offices. The development of better methods in office practice within the last few years has been phenomenal. Devices which would save time and promote accuracy have been eagerly purchased and installed by the principals of every kind of business, and no business has received more benefit from an efficient office system than that of engineers and contractors. Busy men, with their energies centered on the outside, and often times with inefficient help in their offices, were greatly handicapped by the methods in vogue up to within recent years, which prevented not alone the utilizing of every individual's full capacity for work, but caused much mental wory and financial loss as well. To-day, some of the larger concerns have reached such a point of adaptation of modern office devices to their needs that they are able to instantly get at any required information giving the status of any incomplete work, almost up to the moment of investigation.

Card records have been of incalculable service in placing at the disposal of the searcher, minute information regarding any detail of work on hand, unfinished, finished, or prospective. When once an efficient system is installed, and properly maintained, its importance becomes so great that were it withdrawn the depreciation in outside work would be tremendous. In fact, undertakings of large magnitude cannot be prosecuted at the present time without the highest degree of system being maintained in the offices of the construction company, so that every detail can be closely looked after. The Isthmian Canal Commission early recognized this fact and is installing efficient office aids for records of work as it progresses.

Letters and papers pertaining to any one contract are best filed on edge, in vertical file drawers, all papers bearing upon any one subject or contract being contained in an individual folder and entirely separated from any foreign matters, and these folders being indexed numerically by contract numbers. For instance: "327" would contain all papers shown by the index as relating to "Allegheny Tunnel," while, if it were advisable to subdivide correspondence and other matter relating to this contract, "Employees" would be "327-A;" "Materials," "327-2;" "Sub-Contracts," "327-3," etc. The latter system is being utilized by S. Pearson & Sons, of New York, who are engaged in the Pennsylvania R. R. tunnel construction for that road's entrance into New York city.

Turning now to the examples of records and cards, Figs. 1 and 2 show the face and reverse sides, respectively, of a card used in the office of the District Engineer of the Southern Pacific Ry., at San Francisco. This shows in condensed form the essential particulars regarding requisitions for new work or the progress of work under construction. The card is 5 × 3 ins. Requisitions coming in to the District Engineer from different parts of the system are first passed upon by him, and if approved are then forwarded respectively to the General Superintendent, the Traffic Department and the General Manager. If the last approves of the work or requisition the superintendent is authorized, as shown by the heading, and the other two spaces on the face show the date of commencing and completing the work. A contract number is given to the work authorized, which number is placed at the top of the card. A varying series of numbers is used for different classes of improvements, such as "Building Bridges," "Laying Rails," "Repairing Stations," etc.; the cards are also of several colors, indicating the different districts in which the work is located. In the upper right hand corner of the card is noted the amount of the appropriation, and on the lines below is given a brief description of the work, with dates of authorization, commencement and completion. On the reverse side, Fig. 2 (with the column heading across the shorter length of the card), is a monthly record of expenditures; this is classified for labor and material, with the total for each month, and the total from the date of commencement. The cards are filed by the contract numbers, and cross-indexed by subjects as well as by districts. With these and with another series of plain ruled cards, full information as to cost and progress of work can be obtained at any time.

The cards shown in Figs. 3 and 4 are 6 × 4 ins., and are used by the Aberthaw Construction Co., of Boston, Mass. The one shown in Fig. 3 gives a daily summary of the work on any particular job or contract, with account of time put in and material used. The column ruling is the same as the reverse side, so that there are 27 horizontal lines available on each card. Fig. 4 is a

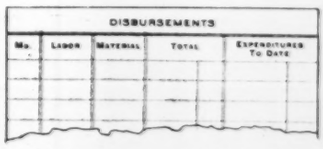


Fig. 2. Reverse Side of Card in Fig. 1.

card giving a weekly summary of the information compiled from the daily cards (Fig. 3). It is of the same size, but with the back blank, and is white in color, while the daily cards are yellow. The company states that its foremen on small jobs, or timekeepers on larger ones, make all their reports to the office on one form of card, for labor and work performed, while another card is used to report materials received. These reports are made out daily and sent to the office three times a week.

The card shown in Fig. 5 is an employee's time record used by the Engineering Bureau of the city of New York, and is one of numerous card records maintained in these offices. It is 8 × 5 ins. in size, printed on buff paper, and it will be seen that each card provides for the daily record of one employee for an entire year. The reverse side is ruled with horizontal lines for remarks.

The keeping up of ledger accounts with contractors by engineers, railway companies, municipal departments, etc., is a matter of great importance, and the headings of a card used for ledger accounts of this kind are shown in Fig 6. The card is 8 × 5 ins., on yellow paper, and both sides of the card are alike. In this way a full record or statement for each contract is shown on the one card, without confusion with other accounts, and the cards are readily filed so that any one account is easily accessible.

Fig. 7 shows a form of card which is used by several large concerns for keeping a record of materials contracted for, and their distribution. It is 8 × 5 ins., on white paper, and the vertical ruling is continued also on the reverse side.

Technical records of construction and repair work are most conveniently kept on cards, and Figs. 8 and 9 illustrate a system of bridge records which has been in use for some time on the Atchison, Topeka & Santa Fe Ry., and has been recently adopted by the Michigan Central Ry. On the face of the index guide card, Fig. 8, which is assigned to each bridge, is given full information as to the location of the bridge, its type, dimensions, age, etc. Behind each index card are filed salmon-colored inspection cards,

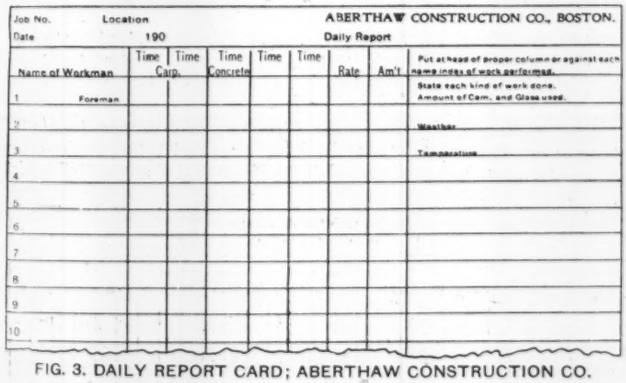


FIG. 3. DAILY REPORT CARD; ABERTHAW CONSTRUCTION CO.

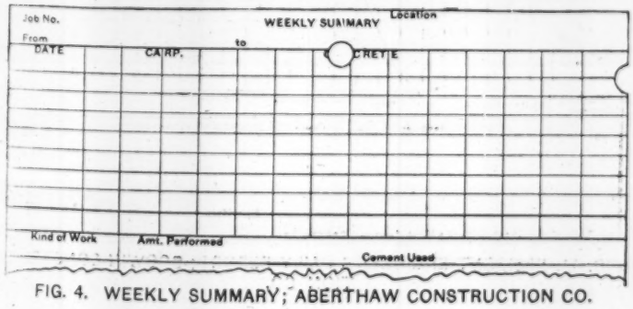


FIG. 4. WEEKLY SUMMARY; ABERTHAW CONSTRUCTION CO.

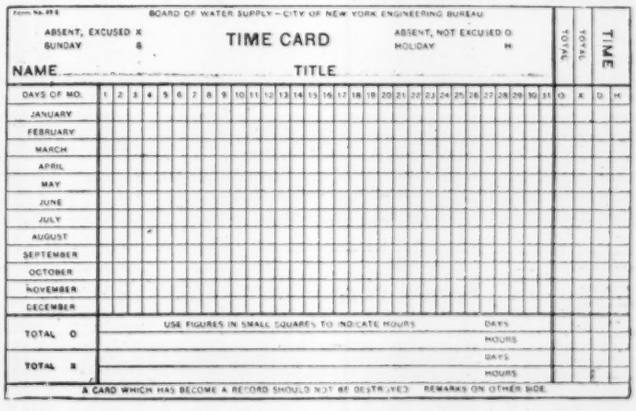


FIG. 5. CARD RECORD OF EMPLOYEES; ENGINEERING BUREAU, CITY OF NEW YORK.

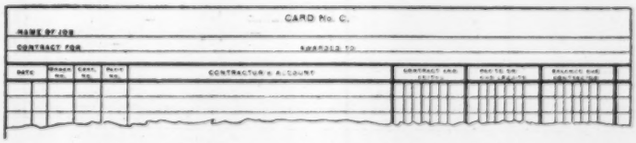


FIG. 6. CARD SYSTEM OF LEDGER ACCOUNTS WITH CONTRACTORS.

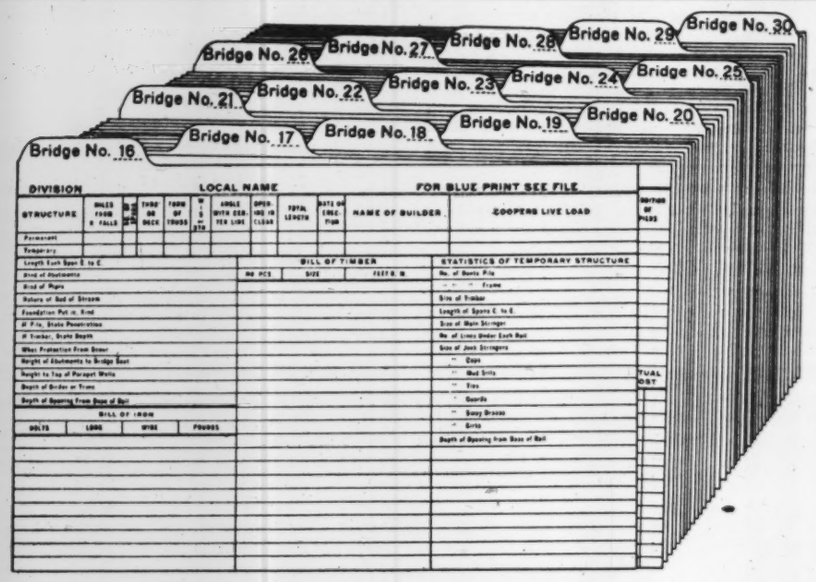


FIG. 8. CARD INDEX FOR BRIDGES; DESCRIPTIVE CARD.

Fig. 9, one for each inspection; these show the condition of the bridge, with the materials and estimated cost for repairs. In this way full particulars of any bridge and the periodical inspections can be seen at any time. The cards can be printed on tough paper thin enough to permit of blue print copies being made. In the arrangement shown by Fig. 8, the indexing is by numbers, and on large roads, those of each division would be numbered and indexed separately. The word "Bridge" need not be repeated in each case, and cards of a different color may be inserted to show the location of stations, these station cards having the name on a raised tag.

The heading of a card used by a firm of contracting engineers for keeping records of work and cost on individual railway contracts is shown in Fig. 10. This is a buff card, 9¾ × 6½ ins., with the reverse side blank. At the head of the card are shown the name and location of the railway; the contract price, estimated cost, and dates of commencement and completion. On the body of the card (with 23 lines for as many weeks) are shown the progress, labor and cost for each week, and also for the entire period ending with each week, together with the percentage of work completed. Thus, by this system, the manager having a large number of contracts in hand can, by looking through the card records, see at a glance how each is progressing, both as to work and cost, and can also at once obtain this information for any one particular contract.

The ten cards described above are illustrative of the various applications of the card system, but the remaining cards are examples of those used by one firm, the Godwin Construction Co., of New York, for the various records required in its business. For particulars of these we are indebted to the company's engineer, Mr. Myron S. Falk. Fig. 11 is a card 6 × 4 ins., for the daily report of the resident engineer of any piece of work. The engineer (or the timekeeper) on each of the company's contracts is required to fill up and mail one of these cards at the close of each day, so that the office is always informed as to the progress of work at any point. On the back of the card (and printed across the narrower width) is the time sheet of the day (Fig. 12), and this is summarized on the face of the card. An inspection of the face, therefore, shows at once the work done, material received, amount of payroll, weather conditions, and the time put in on the work.

In the office these daily time sheet reports are collected or summarized on a weekly report card, 6 × 4 ins., shown in Fig. 13. In order to insure accuracy, the timekeeper on the work is also required to make out one of these latter cards at the end of the week, and this must check with the office records. On the back of this card, which is blank, the timekeeper on the work is required to state the amount of work accomplished. Formerly a paper slip 5 × 10½ ins. was used for the daily report, but the card is much more convenient.

The card shown in Fig. 14 is found to be of the greatest value in obtaining quotations for supplies. It is 6 × 4 ins., and as envelopes of this size are not in general use, a return envelope is always enclosed when sending to a supply house for quotations. The employment card, Fig. 15, is used to enable the office to keep a close record of employees and applicants for employment. The size is 5 × 3 ins., and on the back are headings for the following additional information: 1, References furnished; 2, date of leaving; 3, reason for leaving; 4, date of re-employment; 5, recommendation given.

The ledger accounts are worked up on cards 8 × 5 ins., the style of heading of which is shown in Fig. 16. The headings of the last five columns are given only as examples; the actual headings vary for different classes of contracts. The only book that the office keeps is a cash book, and all entries from that book are entered at once on the ledger cards, so that the different items of cost on any work may be found at once.

In addition to these, the office has a number of other forms of cards for various purposes. All bills that are paid by this company are sent out on vouchers 8½ × 7 ins., folding to 3½ × 8½ ins. for filing. In order to insure proper records of materials, all orders are made out by the company on printed slips of yellow paper 3½ × 8½ ins.; the foremen or inspectors on the various works are furnished with printed slips of pink paper on which they record all materials received.

The use of ledger accounts for individual pieces of work has been referred to in this article, and it is generally recognized that such accounts are of the utmost importance in railway engineering departments, to enable a proper record and account to be kept of individual contracts. The objection has been made that it is difficult to insure accuracy in such accounts, but contracting engineers, who are vitally interested in the matter of cost, find this quite practicable, and there is no reason why it should not be practicable to adopt the same system in railway service. In fact, this system of accounting has been strongly recommended by the American Railway Engineering and Maintenance of Way Association, although its report refers to loose-leaf book records and does not mention card records.

The use of the card-index system in railway motive-power department offices was dealt with in a paper recently presented before the Western Railway Club by Mr. J. H. Wynne, Mechanical

CONTRACT FOR
WITH
DATE
QUANTITY
TERMS
CHARGED AGAINST CONTRACT
ORDER | BILLED | QUANTITY | FOR | ORDER | BILLED | QUANTITY | FOR | REMARKS

FIG. 7. CARD RECORD OF MATERIALS.

BRIDGE NO. INSPECTED 190 BY
ABUTMENTS KIND AND CONDITION
NO. OF POSTS IN BENT
STRINGERS
BILL OF MATERIAL NEEDED FOR REPAIRS
SYMBOLS
ESTIMATED COST OF REPAIRS
ACTUAL COST

FIG. 9. CARD INDEX FOR BRIDGES; INSPECTION CARD.

ENGINEER'S DAILY REPORT
To be forwarded to main office every evening
GODWIN CONSTRUCTION COMPANY,
66 WALL ST., NEW YORK
Date
Weather
Temperature
Location of Work
Section No.
Class of Work
Work Commenced A.M. Worked Ceased M Work Recommenced M Work Ceased M
Class of Labor | Foreman | Laborers I | Laborers II | Laborers III | Laborers IV | Mason | " Helpers | Bricklayers | " Helpers | Carpenters | Timbermen | Rock Builders | Blue Eagle Men | Firemen | Teams | Carts
No. of Men
Total Hours Worked
Pay per Hour
Amount
Rosendale Portland } Cement Used Bags
Coal Received:
Material Received this Day: (Forward receipt tickets with this report.)
Sign Here
On Back of this Sheet, State the Work Accomplished this Day.
Engineer

FIG. 11. RESIDENT ENGINEER'S DAILY REPORT; GODWIN CONSTRUCTION CO.

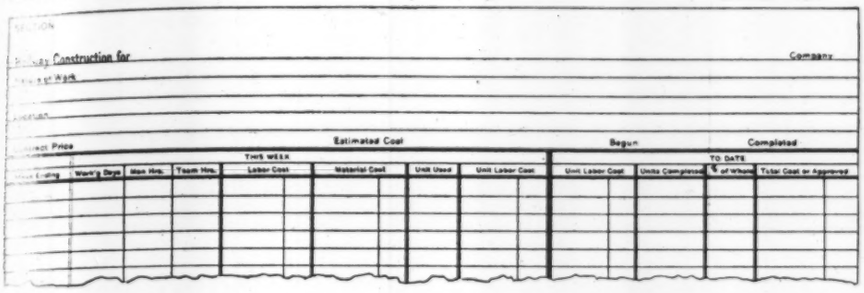


FIG. 10. CARD SYSTEM FOR CONTRACT ACCOUNTS.

Engineer of the Illinois Central Ry. In addition to a description of a number of forms actually used, it was shown that the system was far superior to book records; the latter are unwieldy, not convenient for reference, and lack the flexibility of the more compact card-index system in allowing for alterations and general expansion. Records of locomotives (with their dimensions, mileage, performance, etc.) are kept in this way; also of cars, shop equipment, supplies, water stations (and quality of water), as well as the ordinary card-index for files of drawings.

Card records are also used by municipal engineers in keeping records of street and sewer work, water mains, etc., the cards showing such information as the kind of pavement, sewer, size of pipe, date of construction, contractor, contract prices and total cost, etc. They are also used in keeping record of surveys.

REVIEW OF THE HISTORY OF THE SEPTIC TANK.

At the annual meeting of the Illinois Society of Engineers and Surveyors there was a general discussion upon sewage disposal and the septic tank system, in the course of which a review of the history of the septic tank and of the recent litigation over the patents was given by Mr. J. W. Alvord, M. Am. Soc. C. E., of Chicago. This review, as published in the annual "Proceedings" of the Society for 1906, is given below:

It may be interesting to note the present status of the litigation. The Cameron Septic Tank Co. put its case on last summer in chief, very briefly, and the cities of Madison, Wis., and Lake Forest and Monmouth, Ill., and the Allis-Chalmers Co., combined with Saratoga Springs, N. Y., for the defense. The defendants' case was put on during the summer and completed three months ago. We believe they made out a strong case. The matter is now adjourned to New York for the purpose of hearing expert evidence which the Cameron Septic Tank Co. has to offer. Of course, there is little to be said about the matter until the case is completed, but it looks very much as if it would be very difficult to offset the testimony which is put in for the defense.

The defense first put on Mr. Herbert Snow, who went into a very careful study of the history of the art, bringing out all the publications on the subject about prior uses. It appeared from that study, which was very exhaustively made, that the city chemist of the city of Berlin, about 1880, patented a septic tank, and wrote about it for publication. The patent is quite clear, and it has a very good description of what the septic tank is to-day. He did not use the words "septic tank," and he did not use some other words with which we are familiar, but the idea seems to be well embodied in his patented descriptions. We had also in this study of Mr. Snow much interesting matter, and I hope this testimony is going to be printed and made available, because the study of the history upon this subject is really most valuable and instructive.

It would seem that in England, along about 1852, when sewers first came into use—you are perhaps aware that sewers only came into use about the middle of the century—that the pollution by sewage became so offensive that the subject of sewage purification was taken up. An early report of Mr. Henry Austin goes into a recommendation for what he calls sedimentation tanks, and he cites instances of sedimentation tanks, notably one at Cheltenham and at two other places, and outlines what he considers to be successful sedimentation tanks. This recommendation was followed in England quite extensively for some time. Then came the period in which chemical purification was in vogue. They thought sedimentation was too slow a process, and that the thing could be hastened.

Then came that unfortunate period in which people, instead of accelerating bacterial action, retarded it by using chemicals, increasing, of course, the rapidity with which suspended matters were deposited, but retarding bacterial action and decomposition. That backset to the art lasted fully 20 years. The able advocate of the process, Mr. Santo Crimp, hardly anywhere in his book mentions exclusively sedimentation tanks, and it is interesting to observe that one of the best examples we were able to cite on the art was that of Ealing, in England, of a tank patterned after the recommendation of Mr. Henry Austin, which was used there very extensively for some years. Mr. Crimp's book gives analyses showing remarkable reduction of organic matter due to sedimentation, and the municipal authorities were well satisfied with the works and only altered them on the demand of the higher authorities then existing. That plant, strangely enough, is quoted in Mr. Crimp's book as a failure, whereas all the analyses show it was the reverse, and quite successful. It shows the domination of the

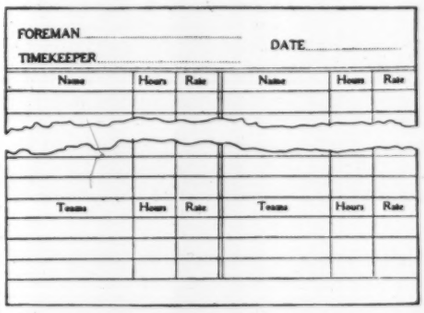


Fig. 12. Time-Sheet on Reverse of Engineer's Card (Fig. 11.)

thought at that time that chemical preparations must be used in order to effect any results.

Then we go along to the interesting fact that Louis Mouras, in Paris, patented his tank four years or so after Alexander Mueller's experiment in Berlin. His tank was designed specially for house use, and was extensively installed in Paris. His work had advantages over the patent of Prof. Mueller in that his ideas were put into operation. Their largest operation was in the works of a gentleman named Hertzog, at Logleback, who put in a considerable installation on the ideas of Mr. Mouras, and the latter's tank was very well exploited. It was described before the English Society of Arts and then before the British Institution of Civil Engineers. It was much quoted from, and in a way that left no doubt about a full understanding of the invention, and the process he was patenting, that there was bacterial action, and that there was reduction; and he even went so far as to claim that the reduction was complete. Then we had Prof. Pagaillinni, of Italy, following closely in the steps of Mouras; he agitated the subject of such tanks, and wrote about them and established one or two near Milan. All the time that chemical precipitation was in such high esteem in England there was nevertheless an undercurrent of opinion among the engineers who were working along sewage disposal lines favorable to sedimentation, and many of them believed in sedimentation, and were building sedimentation tanks. But they were in the minority, and they were so howled down by the advocates of chemical precipitation that it is difficult to find any publication, or any clear statement, of what they really believed and what they were really doing.

Then we come to the early work in this country, and we have what never before so fully appealed to me as it does now, after a careful study, and that is the efficiency of the early work of Col. George E. Waring. He certainly was well ahead of his generation and time in sanitary matters, and particularly in the development of the septic tank. It was very interesting to note that he was driven into an understanding of the septic tank in spite of himself. Imbued with the ideas of the English engineers that foul air from sewage was the cause of disease, he became an ardent advocate of the quick and early removal of sewage from the vicinity of dwelling houses to some distant place, isolated from building. He always urged that decomposition was a terrible thing; a dreadful thing to go on in the vicinity of dwelling houses. That is the strong characteristic of all his earlier writings. But along in 1874 he became interested in the early filtration experiments of the Rev. Henry Moule, who first developed intermittent filtration, and he patented a syphon, by which he was enabled to deposit sewage into the tile drains in intermittent doses. Then, further improving that, he conceived the idea of a separate tank which should precede the flush tank, in which suspended matters might be macerated, or dissolved. He used the word "macerated" where we use "septic action."

Then he took out a patent for the tank which he called "an improved house drain apparatus." He did not use in that patent any words which would lead us to believe that he understood there was organic reduction. But along in the course of his observation on his own patent, noticeably at his own house, in 1876, in Newport, he began to see there was reduction in the tank which he had patented. In this book, published in 1876, he first speaks of noticing that the action was going on, although he does not describe it so very clearly. Other observers who used his ideas also began to notice it; notably Mr. Edward S. Philbrick, of Boston; and in his book, in 1880, Col. Waring comes out with a clear description of reduction, and of its advantage in this kind of disposal. In his 1894 book is also a clear and concise description of the reduction of sewage by maceration and its advantages. It leaves hardly anything to be desired, except possibly the fact that he did not see that, as well as being applicable to domestic use, it was also applicable to towns and large installations. All through his writings, wherever you find them, and the writings of people influenced by his work, you will notice this clear understanding of the maceration, so termed, in his early tanks. He was followed, as I have said, by Philbrick, who described early tanks. He was also followed by Benezette Williams, who invented a flushing syphon, and was associated in business with Col. Waring in the installation of these tanks, and who testified in this case as to Col. Waring's appreciation of this idea, and their enterprise in instructing people in the use of them.

Unfortunately we were not able to obtain as many prior examples of this domestic use as we have desired, because installations are usually made by architects and others who were influenced by Col. Waring's writings, and definite records of them do not exist. We discovered a good many of them and put them on record to establish our claim that a large number existed in this country. I am under the belief that the influence of Col. Waring caused the installation of over 1,000, and possibly many more in this country, at various places. That seems like a large number, but the way in which they have been discovered led to that estimate. Col. Waring's influence was widespread, especially among architects, and you will find traces of it to-day among architects, in their understanding of such matters. All of this work of Col. Waring we showed by his books and by testimony of Mr. Williams very clearly.

Then we came down to the work of Prof. Talbot, who showed clearly the history of his early idea of the septic tank, and definitely linked it back to the Mouras idea, by putting in evidence a letter which he received from Mr. Noyes, of Boston, in 1892. This letter was a very fortunate thing, because it showed the inception of the Urbana tank was directly traceable to the ideas of Louis Mouras, and was not in any way traceable to the influence and experiments of Mr. Cameron which were being commenced at the same time. One of the followers of Col. Waring was Mr. MacHarg, a well-known sanitary engineer of Chicago, who has built disposal plants after Col. Waring's design for a good many years, and he was able to establish two very excellent prior uses; one at St. Joseph's Hospital, near Chicago, and one at Altenheim. To illustrate the way in which that source of the testimony was brought out, I would say that Mr. MacHarg had completely forgotten the fact of the publication of the account of the installation of some of his

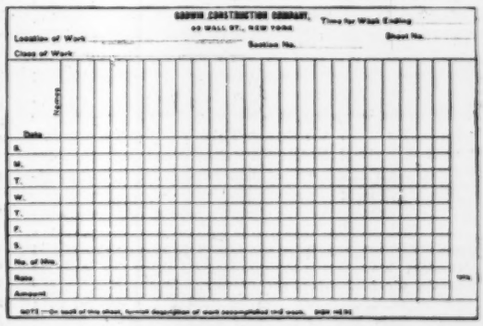


Fig. 13. Card for Weekly Summary of Time Sheets.

QUOTATION | SUBJECT

GODWIN CONSTRUCTION CO.,
60 WALL STREET.
NEW YORK CITY, ... 19

Messrs. .....

Dear Sirs: Please quote hereon your lowest price f. o. b. .....
for the goods mentioned below,
and return this card to us, and oblige,
Yours truly,

A Return Envelope is Enclosed Herewith.

Quantity	Article	Time of Delivery	Quotation
			Sign here

FIG. 14. CARD FOR QUOTATIONS FOR SUPPLIES.

smaller tanks until the cross-examination took place. The cross-examiner thought he had narrowed him down, and tried to make him produce something he had written about a certain small tank. On going over to the library in the noon hour he found in the "Inland Architect" a complete description which we put on record. In bringing in Mr. Hill, an architect of Chicago, who was connected with the St. Joseph's Asylum, to corroborate his testimony, it suddenly occurred to Mr. Hill, while he was on the stand, he had built one like it at St. Bedes College at Peru, Ind., and when the cross-examiner wanted him to back down on the statement he got more positive. We finally went down to Peru and made surveys, and brought back the Reverend Father from the college, who testified all about it. It showed clearly that the idea was fully understood and copied and was a matter of common knowledge at that time.

We had evidence of other prior uses, notably one at Independence, which, through the illness of the principal witness, we were not able to put on. It was thought we had sufficient proof to make a case, and the evidence was then closed by another review of the history of the art by myself, corroborating Mr. Snow's evidence.

There are two English patents on the Cameron method. The earlier one, which is not very specific or complete, was in 1894. There is a second English patent which is much broader, and more complete in its description, in 1895; the United States patent was filed in 1897, but it was not finally granted until 1899, having been two years in the patent office, subject to some controversy. It is unnecessary, of course, in showing priorities to go back of the first English patent.

THE VENTILATION OF THE SIMPLON TUNNEL.

The great Simplon tunnel, completed this year and opened for traffic on June 1, is to be operated by electric traction, but pending the completion of the electric installation the trains are hauled by steam locomotives. Under these conditions the question of ventilation is of importance, and we give below an extract of a report published in "The Engineer," of London. The tunnel is 12.4 miles long, and will consist of two single track tunnels, but at present only one is in service; this is of horseshoe section, 13 ft. 7 in. wide at the rail level, 16 ft. 5 ins. at the widest part, and 18 ft. high above the rails, the area of cross-section being 250 sq. ft. The summit is 2,310 ft. above sea level for about 1,650 ft., with down grades of 0.2% to the Swiss portal near Brieg [1,476 ft. elevation], and 0.7% to the Italian portal at Iselle [2,070 ft. elevation]. The central portion is straight, but each end is on a curve. There is a permanent ventilating plant at each end, the equipment in each case being in duplicate for the two separate tunnels. For each end of each tunnel there is a fan 12.3 ft. diameter, driven at a speed of 400 revolutions per minute by a 200-HP. turbine. This ventilating system was described in Engineering News of Aug. 20, 1903. An abstract of the report in "The Engineer" follows:

The ventilation of the Simplon tunnel, although ordinary coal-burning locomotives are in use, has proved a great success, and there are scores of short unventilated tunnels, down to one mile in length, where the condition of the air is far less satisfactory. In the Simplon the forced ventilation has also to subdue the natural rock heat. This heat is the only inconvenience passengers suffer. It is slight, and endures for a short portion of the journey, and it cannot be expected that electrical working will cause the least appreciable diminution of it. The ventilation is, in fact, admirable. Independent observers riding with the car windows open for the whole length of the tunnel testify to the purity of the air even in the most heated region, and the engine-men admit that there is no smoke or other inconvenience for them save the natural heat of the tunnel. The popular notion that the tunnel is badly ventilated is largely due to the action of the train conductors, who close the windows; but it appears difficult to persuade them to the contrary while passengers, with starting eyes, view the opening of a window as criminal. The benefits of artificial ventilation are lost when the entrance of the continually-renewed and fresh air is resisted. Riding with windows wide open all the way reveals the fact that the ventilation is, even with the steam locomotives, very perfect indeed, and leaves no condition to be desired other than the suppression of the moist hot-house heat towards the middle part of the tunnel; and this detail, of no consequence even to the least robust person, can never be overcome by any system of traction whatever.

The tunnel was opened for regular traffic on June 1. At present there are seven or eight passenger trains daily in each direction, besides a tri-weekly "limited." The line from Aigle to Arona is single, but all Italian tunnels are built to accommodate double tracks.

The following notes relate to journeys made on June 9: Start from Domodossola at 2 p. m. with two freight locomotives [2-8-0] heading the train. Temperature in cars 72.5° F. The helical tunnel at Varzo [1.86 miles in length] is entered at 2.24 p. m. with a rush. The temperature in this and the following straight tunnel of Trasquera rises from 73.4° to 75.2° F. Iselle station is reached at 2.33, or at an average rate of about 20 miles per hour. Here the pilot locomotive is discharged while the train engine fires up. Start at 2.37, and enter the long tunnel at 2.38. In a few seconds, in curved portion of tunnel, air is a little sulphurous, but soon becomes fresh, and continues so upon the up grade, although the heat increases after about 2½ miles. Five minutes later [2.43] the condensed vapor begins to run down the windows in those cars where they have been kept closed. The moisture in the outside air is palpable to the hand. At 2.44 the temperature in the closed up compartments has risen to 77° and at 2.47 increases to 78° F., the outside air meanwhile being pure and non-sulphurous. The station in the middle of the tunnel is passed, and the falling grade then commences. Here the windows are pulled down, but despite the fresh, cooling air then entering the cars, the temperature continues to mount to the ultimate maximum of 80.6° F. The temperature then falls; at 2.58, to 77°; at 3 p. m., 75.2°; at 3.02 to 72.5°; at 3.03 to 71.6°, and at 3.04 to 69.8° F. At 3.05 the train emerges by the north portal, and three minutes later reaches Brieg station, the speed in the tunnel having averaged about 28 miles per hour. The motion of the cars in the tunnel is practically smooth. The temperature at the middle portion of the tunnel appears to vary very little.

The return journey to Domodossola is commenced at 3.48 p. m. There are only nine cars in the train [eight six-wheeled and one double-truck car] drawn by an eight-coupled locomotive. The temperature inside the cars at Brieg is 67.1° F. At the north portal it is 68°. The tunnel is entered at 3.51. The car windows on both sides are kept open almost constantly. The temperatures noted are as follows: At 4 p. m., 69.8°; at 4.03, 73°; at 4.05, 74.7°. The tunnel station is already passed, the summit of the line, and the air outside is now perceptibly cooler to the hand, but the thermometer continues to record a slight increase of warmth: at 4.07 of 75°, and at 4.08 of 76°. At 4.09½ the train leaves the tunnel, entering Iselle station at 4.11.

The speed in traversing the tunnel averaged 37½ miles per hour. The air was pure and entirely free from sulphurous gases and smoke throughout the whole length of the tunnel, although hot and damp in its mid-length. In this respect the observations of two independent observers in the same car concorded exactly with those of the driver of the train. As the windows were kept open the whole time on the falling grade, and almost constantly so on the rising grade, the traveling conditions were of the very best; the vitiated air usually generated in the car was absent, and no steaming of the windows occurred. At Iselle station the car temperature remained at 75.2° F., the outside temperature being much less. Thence the temperature dropped continuously, being 74.3° in descending through the helical tunnel of Varzo [1.86 miles in three minutes], 73.4° just below the tunnel, and 72.5° F. in Varzo station.

These results were compared with the ventilation of the Gothard tunnel on the following day, at about the same hour, in the direction from Airolo to Goeschenen. The air in this latter case was noticeably cooler throughout, but in the first part of the tunnel the cars were penetrated by a mildewy odor. For the greater part of the time the air passing by the cars was pure, and at no time was it charged with sulphurous odor to any objectionable extent. The air of the old London underground Metropolitan Ry. when operated by steam used to be very much more so, while the vitiation of air in the present Paris Metropolitan Ry. [underground] is unquestionably still more serious, microbiologically. On the whole, the long Alpine tunnels provided with mechanical ventilation appear to furnish the best examples of aeration, although they are, of course, subject to occasional intervals of inferior results, due to greater frequency or volume of traffic, or to adverse outside meteorological conditions. In the Simplon, the line being single, no conflicting air currents can be set up by the crossing of trains such as, with steam locomotives, it is desirable to avoid to obtain the best ventilation.

GODWIN CONSTRUCTION CO. 60 WALL ST., NEW YORK.

Application for employment ..... Date .....
Name ..... Entered our employ .....
Address ..... Rate per .....
City ..... Rate changed .....
Age ..... Married ..... Where last employed .....
Reason for change ..... How long there ..... Wages .....
Where second last employed ..... What trade .....
How long worked at it ..... Union member .....
What union ..... THIS INFORMATION RECEIVED BY

Fig. 15. Card Record of Employees.

A STATE HIGHWAY COMMISSION IN VIRGINIA has been established by a legislative act. The commission is composed of four men: A state highway commissioner, appointed by the governor for six years, and the professors of civil engineering at the University of Virginia, the Virginia Military Institute, and the Virginia Agricultural and Mechanical College. The commissioner must be a citizen of the state, "a civil engineer and a person well versed in road building." He is to be paid $3,000 a year, and traveling expenses, and to be provided with an assistant engineer at $1,800 a year, and expenses, and a clerk at $1,200 a year. The three professors are to be paid actual expenses, only. Other assistants and clerks may be employed by the commissioner, with the approval of other members of the commission and of the governor. The commissioner is to gather information and statistics on road building and maintenance and disseminate the same "through farmers' institutes and the bulletins of the board of agriculture, or otherwise," and he must also submit an annual report to the governor. The commissioner is to pass upon applications from county road authorities for road improvements by means of convicts, and make plans and estimates for such roads. The commissioner is to have "a general supervision of the construction and repair of the main traveled roads of the state," and "may recommend to the local road authorities of any county, and to the governor, needed improvements in the public roads," and must "supply technical information on road building to any citizen or officer in the state." The commissioner may consult with any one or all of the professors named regarding "any engineering problem confronting him." A companion act to the one just outlined provides in detail for a state convict road force. The office of the state highway commissioner is at Richmond, Va. A pamphlet containing the two acts named has been printed, and presumably may be had by sending name, address and a postage stamp to the commissioner.

CONTRACT OF GODWIN CONSTRUCTION CO., AT .....
60 WALL STREET, NEW YORK. SHEET NO.

VOUCHER No.	DATE	PAID TO	TOTAL	LABOR	CEMENT	LUMBER	COAL	SUNDRIES
		FORWARD						

FIG. 16. CARD FOR LEDGER ACCOUNTS FOR INDIVIDUAL CONTRACTS.

THE TRACK CONSTRUCTION OF UNDERGROUND RAILWAYS.

When underground railways for city traffic were first built, the track construction was given little attention, the ordinary type of railway track being adopted as a matter of course. The same practice has been followed on several of the more recent lines, but with some important exceptions. The question of track construction for lines of this class is discussed in another column, and we give herewith descriptions of the types of track adopted for a number of American and foreign underground railways.

NEW YORK CITY.

RAPID TRANSIT SUBWAY.—The subway lines built by the Rapid Transit Railway Commissioners, and operated by the Interborough Ry. Co., are in general of rectangular section, having a flat concrete floor, with steel columns and roof framing embedded in concrete side walls and roof. Between the tracks are rows of columns supporting the roof. It was originally intended to have a special track construction, shown in our issue of Dec. 14, 1899. For each line of rails there was to be a separate trough 12 ins. wide, formed of an outer 8-in. and an inner 11-in. channel, resting upon and bolted to a transverse tee-bar 4 × 2 ins. forming a cross tie for the two troughs of each track. These ties were to be embedded in the concrete floor, while at the outer sides the concrete was to be filled in flush with the top of the 8-in. channels. The 80-lb. rails were to be supported in these troughs by a continuous bearing of transverse wooden blocks 4 ins. thick, 12 ins. long and 8 to 12 ins. wide. Longitudinal timbers were to be laid against the web of the rail as fillers. The 11-in. channels projecting above the rails would form continuous guard rails, and such a floor system could readily be flushed and cleaned. This plan was not followed out in construction, however, but the ordinary style of track with rails on wooden ties embedded in ballast was adopted.

This track construction is shown in Fig. 1. The rails are of the Am. Soc. C. E. 100-lb. section, and are in lengths of 35 ft.; they are laid with broken suspended joints and are spliced partly with the Weber joint and partly with a 24-in. four-bolt angle bar joint. The rails rest on ¼-in. steel tie-plates, 8¾ × 5 ins., and are secured by ordinary spikes. The ties are 5 × 8 ins. section, 8 ft. long; every fourth tie, however, is 8 ft. 6 ins. long, carrying the insulating supports for the 75-lb. third rail. They are spaced 22½ ins. c. to c., except that the two ties at each joint are 18 ins. c. to c. The flat concrete floor has a trench 10 ins. deep and 8 ft. 10 ins. wide, in which the ties are laid on 5 ins. of ¾-in. stone ballast; the ballast is filled in between the ties and around their ends, as shown. As the railway has been in operation for little more than a year there has not yet been any renewal of the ballast. The motor cars weigh 95,400 lbs., with 58,400 lbs. on the motor truck.

We are informed by Mr. George H. Pegram, Chief Engineer of the Interborough Rapid Transit Co., that the present track is satisfactory where the ballast is not less than 5 ins. deep. Mr. Geo. S. Rice, Chief Engineer of the Rapid Transit Railway Commission, also states that it is satisfactory, except that the stone ballast produces a certain amount of dust and at the same time gathers oil dripping from the cars; both of these conditions are objectionable in a tunnel. The sanitary and atmospheric conditions of the New York subway have been fully discussed in our columns. In an address before the New England Railway Club, Mr. Rice made the following comments upon the track construction above described:

> The track is laid with 100-lb. rails and is ballasted in broken stone, with the ordinary ties. This is due to one of the differences which we had with our contractor. In the beginning, in studying this problem of the track, we laid out an entirely different kind of track. We did not think it was necessary to use ties. We were underground, with no frost, and there did not seem to be any reason why we should use a tie or should use ballast; we wanted to use concrete. We had constructed on Long Island, near Jamaica, an experimental section of track which was used for one winter, and it showed up very well. My own idea is that we should have a solid track, and I think that we are coming to it now. The present track, however, is admirable. I do not know an easier running road. It has been a success, but, of course, the cost has been very great to maintain it under the traffic of heavily loaded express trains, eight cars long, and running at great speed almost continuously from the beginning of the year to the end.

A criticism of this construction often made is the extreme difficulty of renewing ties. Practically this cannot be done without raising one or both rails high enough to permit raising the tie above the concrete wall at the side or else by removing the rail entirely. A glance at the cross-section shows it to be impossible to shove the tie endwise as is done on ordinary railway track.

Of course as all the ties are new and they are laid in a tunnel where they are protected from the weather it will probably be some years before renewals will become necessary. Sooner or later, however, under the very heavy traffic, these ties must wear out; and the problem of what to do under such conditions to keep the track in good order will be a very difficult one.

LONG ISLAND RY.—The Atlantic Ave. subway of the Long Island Ry. is a double-track rectangular structure with concrete invert and side walls, and a roof of concrete jack arches between transverse I-beams and plate girders. The clear width is 26 ft., with tracks 13 ft. c to c. The tracks are of ordinary construction, with rails laid on wooden ties embedded in stone ballast; the ballast is from 6 to 32 ins. deep beneath the ties (owing to the curve of the floor) and is sloped down in the middle to a box drain. Both motor cars and electric locomotives are operated; the former weigh 29,110 lbs., with 16,761 lbs. on the single motor truck; the electric locomotives have eight wheels and weigh in working order about 180,800 lbs. Mr. J. B. Austin, Jr., Engineer of Maintenance-of-Way, states that the track construction is satisfactory.

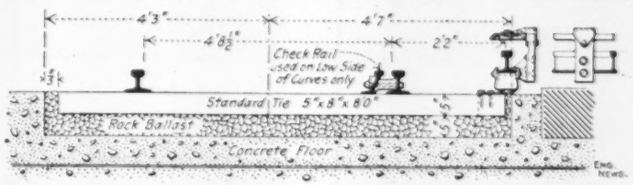


FIG. 1. TRACK CONSTRUCTION IN THE NEW YORK SUBWAY.

This road was described in our issues of May 22 and Dec. 18, 1902.

OTHER LINES.—The track construction for the electric lines in the terminal tunnel of the New York Central Ry. has not yet been determined, but different types are now under consideration. At present, the tracks (as operated by steam locomotives) have 100-lb., 33-ft. rails, laid with broken three-tie joints spliced with 36-in. six-bolt angle bars. The rails are secured by Goldie sharpened spikes to 6-in. ties, 8 to 10 ins. wide and 8 ft. long, with 20 ties to a 33-ft. rail length. The ballast is of broken stone, 12 ins. deep under the ties, and is turned over with forks every year to remove the dirt and dust. The heaviest locomotives using these tracks weigh 107.5 tons (171 tons with tenders); they are of the 4-6-2 type, with 47,000 lbs. on each of the three driving axles. For the Hudson River and East River tunnels of the Pennsylvania R. R. the track construction has not been determined upon; each track is to be in a separate circular tunnel, with concrete floor.

The original plans of these tunnels, published in our issue of Oct. 29, 1903, showed vertical side walls close to the clearance line for a height of 6 ft. above the rails, so that a derailed car would be held close to the rails. The upper part of the tunnel is 9 ft. 6 ins. diameter inside, while the width between the vertical sides is 11 ft. 8 ins. Refuges are formed in the sides at intervals. For the wide three-track and four-track tunnel extending from the river tunnels to the terminal station, the plans referred to showed a concrete floor with steel longitudinals embedded in it. Each longitudinal was to consist of two 12-in. I-beams set side by side, spliced with flat plates and six bolts (in two vertical rows), spacing sleeves being fitted between the I-beams. The two longitudinals for each track were to be connected at intervals by flat tie-bars riveted beneath the bottom flanges of the I-beams, and a wide drain or ditch was to be formed in the concrete in the middle of each track.

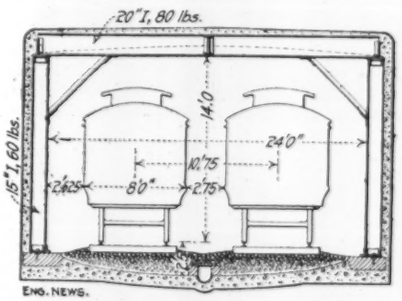


Fig. 2. Track Construction in the Boston Subway.

BOSTON, MASS.

RAPID TRANSIT SUBWAY.—The subway lines were built by the Boston Transit Commission and for operation they are leased to the Boston Elevated Ry. Co., which also controls all the surface and elevated lines of the city. The general track construction is shown by the cross section, Fig. 2. In the subway lines the tracks for trolley cars are laid with 85-lb. tee rails of the Am. Soc. C. E. section, having 42-lb. guard rails bolted to them, as shown in Fig. 3, the bolts being about 23 ins. apart; the vertical web of the guard rail is cut away at joints to clear the splice bars. The rails are laid with broken, suspended joints, spliced with the Continuous joint and eight bolts. The Goldie tie-plates and Goldie sharpened spikes are used. The ties are 6 × 8 ins., 6 ft. 6 ins. long, and the ballast is 6 ins. to 24 ins. deep under the ties. The ballast is of broken stone, of 2½ in. size to within 2 ins. below the ties and then 1-in. stone to the tops of the ties. There has been no renewal of ballast since the lines were constructed except for small repairs. These lines are operated by four-wheel, six-wheel and eight-wheel (double truck) trolley motor cars, weighing 18 to 30 tons.

For the East Boston tunnel, a modified construction is employed. The rails are of the 85-lb. Am. Soc. C. E. section, in 60-ft. lengths, laid with broken suspended joints spliced with a four-bolt Weber joint having bars 24 ins. long. The Goldie claw tie-plates and Goldie sharpened spikes (⁹/₁₆-in. × 5½ ins.) are used, the latter being driven in an inclined position, as shown

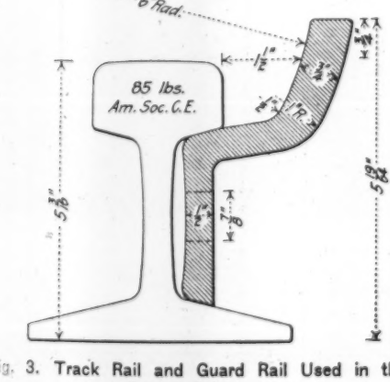


Fig. 3. Track Rail and Guard Rail Used in the Boston Subway.

by the section in Fig. 4. Continuous guard rails of special section are used, resting on tie-plates and bolted to the track rails at intervals of 5 ft. (or 2 ft. 6 ins. on sharp curves and at special work); spacing blocks are fitted between the track and guard rails, giving a flangeway of 1¾ ins., which width is increased as required on sharp curves. The guard rails weigh 57½ lbs. per yd. and are in 30-ft. lengths. The ties are of hard pine, 6 × 8 ins. in section, and 7 ft. long, except that every third tie is 8 ft. long in order to carry the third-rail supports. The stone ballast is from 6 to 23 ins. deep under the ties, and is of 2½-in. stone for the lower part and 1-in. stone for the upper part. It is drained by side openings into a central concrete drain. The double truck motor cars weigh from 24 to 43 tons. Mr. A. L. Plimpton, Engineer of the Boston Elevated Ry. Co., states that the track construction is satisfactory.

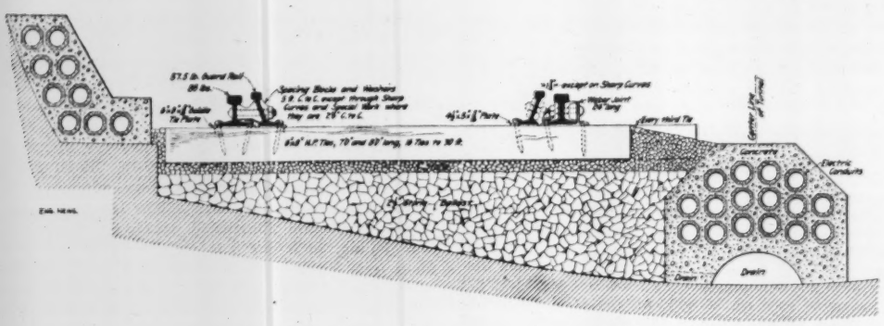


FIG. 4. TRACK CONSTRUCTION IN THE EAST BOSTON TUNNEL.

PHILADELPHIA, PA.

PHILADELPHIA RAPID TRANSIT RY.—In the subway line built by the Philadelphia Rapid Transit Co. a concrete floor is used, without ballast, so that it can be easily swept or flushed and so kept free from dirt and odor. This is shown in Fig. 5. The line has a four-track subway of rectangular section, with three rows of columns between the tracks. Its construction (not including the tracks) was described in our issue of Dec. 29, 1904. The two middle tracks are for express trains and have under each rail a longitudinal girder composed of two 12-in. vertical channels connected at intervals by two 15-in. horizontal channels; these are embedded in concrete. Across the flanges of each girder are laid wooden blocks 24 ins. long, 6 ins. thick and 10 ins. wide; these are held in place by bolts, and to them the rails are secured by screw spikes and clamps. Longitudinal drains on each side of each track are connected with a central drain by transverse drains 90 ft. apart; in the middle of the track are rectangular sumps 500 ft. apart. The two outer tracks are for local trains, and have cast-iron chairs embedded in the concrete, with 4-in. tile drains from the side drains to the center main drain and sumps, which latter are 50 ft. apart in these tracks. The chairs are 5 ft. apart, and the rails are secured to them by tap bolts and clamps, while horizontal screws in the ribs at each side of the rail seat allow for lateral adjustment of the rails. This latter construction is the same as that used on the company's surface lines (with which these outer tracks connect), and has been found very satisfactory on those lines. After the tracks are finally adjusted and concreted, the rail fastenings are covered up by the concrete filling. Both forms of track have been in use since December, 1905, and Mr. Wm. S. Twining, Chief Engineer of the Philadelphia Rapid Transit Co., states that so far they have met all requirements and proved entirely satisfactory. Fig. 6 shows the rails and chairs for one of the local tracks set in position ready for the concrete. Fig. 7 shows another part of a local track ready for the top filling of concrete around the rail heads, and a part of the track in the rear of the view has this filling in place; at the left are seen the rails and blocks of one of the express tracks.

The rails are of the 90-lb. Am. Soc. C. E. section, in 60-ft. lengths, with Weber joints on the two inner tracks and the Lorain Steel Co.'s special joint for the outer tracks, similar to that used with grooved girder rails on the company's surface lines. As shown in Fig. 8, the splice bars are finaged out at the top to the width of the rail head and extend under the rail base; they only touch the web of the rail, however, melted zinc or spelter being poured in to form a 3/16-in. filling under the rail head and around the rail base. These bars are 32 ins. long with six bolts spaced 4 ins. c. to c. On the inner tracks the rails are laid with broken supported joints; on the outer tracks, the joints c[illegible] between the chairs but the rails are suppo[illegible] for their entire length by the continuous bed [illegible]ncrete. All cars on these lines are mot[illegible]rs; those on the inner tracks have two mot[illegible]nd those on the outer tracks four motors pe[illegible]

LONDON, ENGLAND.

The numerous underground railways o[illegible]don include the several "tube" lines (with [illegible]ircular tunnel for each track), double-track [illegible]ck tunnels, and a shallow subway for street c[illegible]

METROPOLITAN RY.—This is one of t[illegible]old underground railways, recently converted [illegible]om steam to electric traction, and is mainly a d[illegible]ble-track brick tunnel of horseshoe section, 28 ft. 6 ins. wide. It is laid with the ordinary E[illegible]lish type of track, having 86-lb. bull-head r[illegible]32 and 24 ft. long, carried in cast-iron cha[illegible]s secured to the wooden ties with two [illegible]g-bolts, or two spikes and two trenails t[illegible]ach chair. The rails are laid with square sus[illegible]led joints, spliced with 18-in. splice bars and four bolts. The ties are 5 × 10 ins., 9 ft. long, s[illegible]ed 2 ft. 8½ ins. c. to c., and laid in stone (flint) ballast having a depth of 18 ins. beneath the ties; the ballast is renewed in from four to ten years, depending upon the locality and traffic. Mr. E. P. Seaton, M. Inst. C. E., the Chief Engineer, states that the track construction is satisfactory. The stations are about 1½ miles apart, with intermediate ventilating openings in many cases, but there is no special provision for ventilation, and this has caused some trouble. There is a main box drain between the tracks (on the tunnel invert) and there has been no trouble with drainage except in a few cases where water has backed up into the tunnel owing to the overflowing of the public sewers. There has also been trouble due to high temperature, but very little complaint as to the noise of the electric trains, although the steam trains were very noisy. The double-truck motor cars weigh 40 gross tons, while the electric locomotives (also with double trucks) weigh about 45½ gross tons.

METROPOLITAN DISTRICT RY.—This is another old line, and is in general similar to the Metropolitan Ry., but for a considerable part of its length it was built in open cut and is of rectangular section, with brick floor and walls (the latter recessed to form jack arches), and a roof of brick jack arches between transverse beams. The track construction is of the same general character as that above described, with rails in 24-ft. lengths to admit of their being turned in the tunnel. The ballast is of gravel. In an article in "The Engineer," of London, some doubt has been expressed as to whether the track is strong enough for the new electric equipment. The reason for this doubt is the rapid wear of rails and the somewhat frequent break-

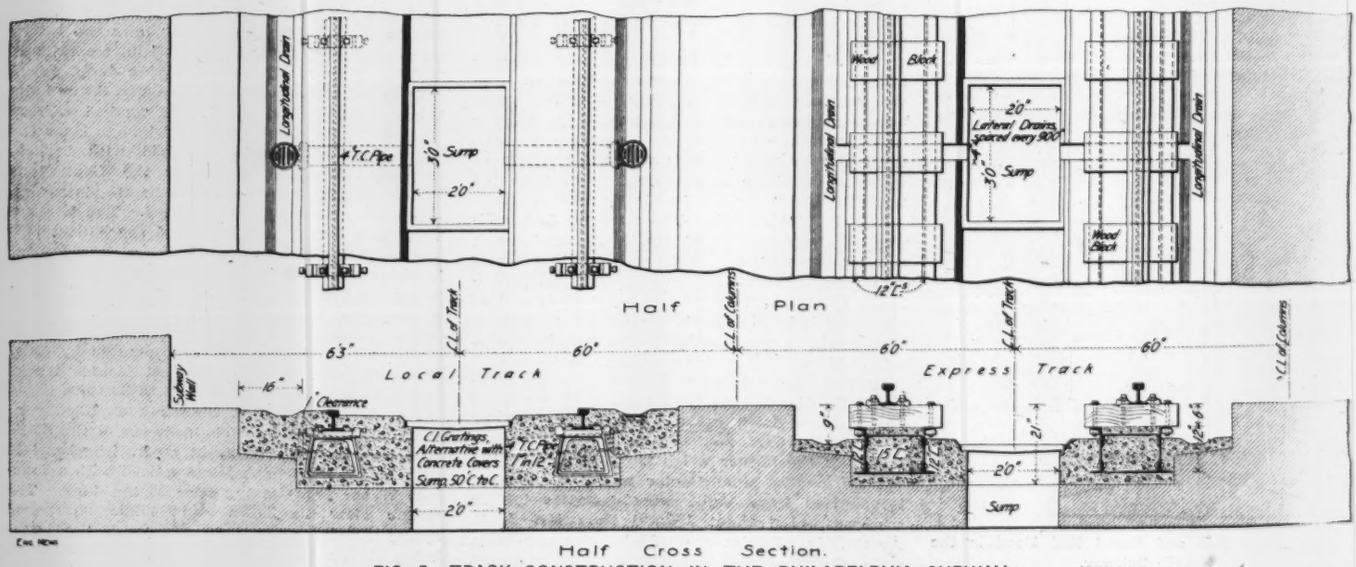


FIG. 5. TRACK CONSTRUCTION IN THE PHILADELPHIA SUBWAY.

age of axles, the axles being generally those on the trailing or non-motor trucks of motor cars. The increased difficulties in maintenance of way due to the presence of cables and live rails and the more frequent service of trains are also considered to have an influence upon these conditions.

CENTRAL LONDON RY.—This is one of the most important of the several modern "tube" lines. As originally built (Eng. News, April 12, 1900) each of the iron-lined single-track tunnels had a concrete floor hollowed out to form a wide drain; longitudinal timbers 5 ins. thick and 11 ins. wide were laid on benches at the edge of the drain, so that their tops were flush with the top of the concrete floor, and between these longitudinals were transoms or transverse timbers 5 × 5½ ins., spaced 7 ft. 6 ins. c. to c. Alternate transoms were secured by strap bolts, spiked or bolted to their sides, the round part of the bolt passing through the longitudinal and having a nut on the end. The other transoms were simply secured by spikes. Upon the longitudinals were laid 100-lb. rails of bridge section, 7 ins. wide but only 3½ ins. high, secured by bolts 2 ft. 8 ins. apart, staggered on opposite sides of the rail base, those on each side being 5 ft. 6 ins. apart. The bolts were screwed down from above, with the heads bearing on the base of the rail and the threaded ends passing through large triangular fang-nuts on the bottom of the timber, the nuts having points or fangs at the corners to bite into the wood and so keep them from turning as the bolts were screwed down. The rails were laid with square joints, and were not spliced in any way. A ribbed base plate ½-in. thick, and 7 × 20 ins., was put under the joint, the ribs fitting the interior groove of the bridge rail, and eight fang bolts were used. Pockets were formed on the concrete under the longitudinals to enable the track men to get at the nuts, and as these pockets were 19 ins. long at the joints an oak block was put in at the middle to prevent deflection under the rail ends.

Soon after the opening of this railway, however, severe vibrations became evident in many buildings along the route, and the matter became so serious that in 1901 a special commission was appointed to make a thorough investigation. The reasons for this vibration were found to be the lack of rigidity in the rail, the uneven surface of the rail head, and the use of electric locomotives in which a considerable proportion of the weight was not carried by springs. The clearance in the tunnels was so small that no change in the track could well be made, but the committee recommended the use of stiffer rails in future lines of the same class. The remedy adopted was the abandonment of separate electric locomotives and the introduction of motor cars on the multiple-unit system (Engineering News, March 13, 1902).

BAKER ST. & WATERLOO RY.—For this "tube" line, which was opened only a few months ago, a combination of concrete floor and ballasted track has been adopted, the arrangement of which is shown in Fig. 9. It would seem,

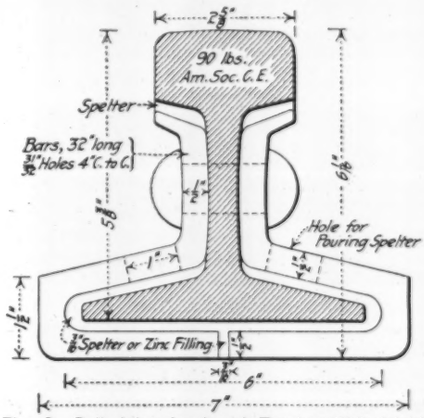


Fig. 8. Rail Joint for Local Tracks; Philadelphia Subway.

however, to be unnecessarily complicated, and that the ballast might have been omitted with advantage. The 90-lb. rails are of the English bull-head section, in lengths of 35 and 37 ft. so as to keep the joints square on both tangents and curves. The rails are carried in cast-iron chairs having a base area of 7 × 13 ins., the chairs being secured to ties of Australian hardwood by screw spikes insulated from the chairs by fiber sleeves and washers. A ¼-in. felt pad is placed under each chair. The ordinary ties are 5 × 14 ins., and 6 ft. 6 ins. long, but those carrying the insulating chairs for the conductor rails are 6½ ins. longer; they are spaced 3 ft. 4 ins. c. to c. At the rail joints, however, the ties are 5 × 10 ins., spaced 22½ ins. c. to c., and the joint chairs have the rail seats projecting about 10 ins. so as to support the overhanging portions of the rail ends. The joints are spliced with four-bolt bars. Owing to the length of the ties they are necessarily placed between the flanges of the iron lining of the tunnel, and their ends are beveled from below to clear the lining. The conductor rails are of rectangular section, weighing 85 lbs. per yd.; the positive or collector rail is 3 ins. above the track rail and 16 ins. from the gage side of the latter; the negative or return rail is laid along the middle of the track, with its top 1½ ins. above the track rails.

The concrete filling in the bottom of the tube is of peculiar section, being raised at the middle so as to project 3 ins. above the bottom line of the ties for a width of about 3 ft. 10 ins. This is hollowed out to form channels for the ties, which are leveled up by bedding them on about 1¾ ins. of cement grout. Three pieces of angle iron are spiked across the bottom of each tie; in renewals, the middle piece comes up with the tie, its flange leaving a groove in the concrete as a guide for placing the new tie, whose ends also are bored to fit the spikes in the end angle irons which remain embedded in the concrete. The width of the concrete bearing is such that the ends of the ties carrying the chairs and rails are entirely unsupported by it, but fine crushed granite ballast (broken to a ¼-in. ring and washed) is packed under the overhanging ends and filled in level with the tops of the ties. The track is thus permanently and intentionally center-bound, and any deflection of the ends of the thin ties (which must occur under traffic) will gradually crush and displace the ballast, resulting in dust which will be liable to cause injury to the car motors and bearings and discomfort to the passengers. The object is said to be to prevent the noise and hard riding which might be expected with ties laid on a solid floor, but the construction certainly does not look promising from a maintenance point of view. No trouble with the track has yet developed, but it is too early for any definite results to be known. It is reported, however, that the noise is not appreciably less than in other similar railways. The same construction has been adopted for other tube lines which are being built by the same company, the Underground Electric Railways Co. Mr. James R. Chapman, Chief Engineer for this company, states that the Baker St. & Waterloo Ry. has been running trains at 3-minute intervals for some months, and that the track has developed no defects. Exhaustive tests have been made in regard to vibration, using seismographs in the basements and upper floors of houses adjacent to the line; although trains passed at full speed beneath these houses while the observations were being made, no appreciable vibration was discovered.

All of the three tube lines mentioned are

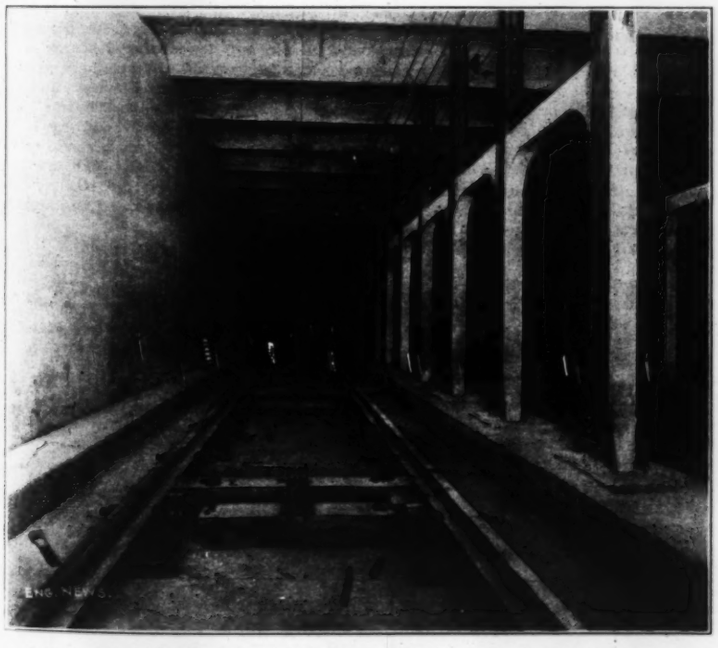


FIG. 6. LOCAL TRACK READY FOR CONCRETE; PHILADELPHIA SUBWAY.

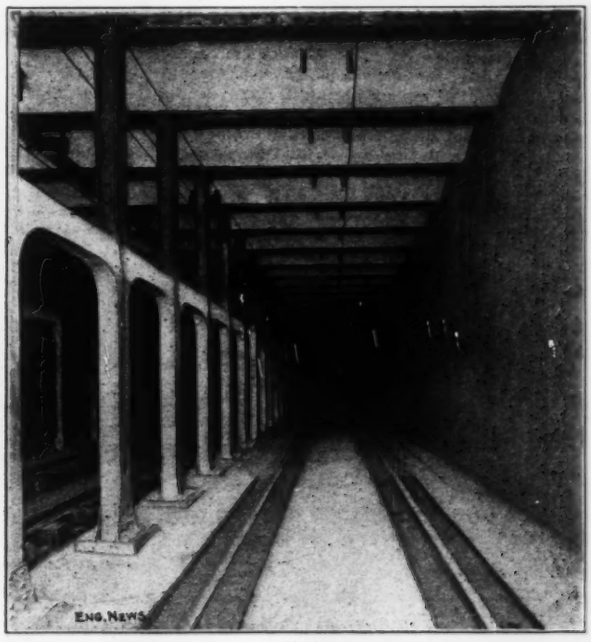


FIG. 7. LOCAL AND EXPRESS TRACKS; PHILADELPHIA SUBWAY.

equipped with exhaust fans which remove 18,600 cu. ft. of air per minute from each low level station, and observations taken during the first two months of operation of the Baker St. line indicated that the temperature was being kept within 2° or 3° of that in the streets above. As the lines are in the London clay, which is practically dry, no drainage system is required. A porous tile drain, however, is carried in the concrete under the ties, and the trifling amount of water from condensation is removed from small sumps (each holding a barrel or more) placed at the foot of all grades. Sometimes a tank car for this work is only run at intervals of four to six weeks.

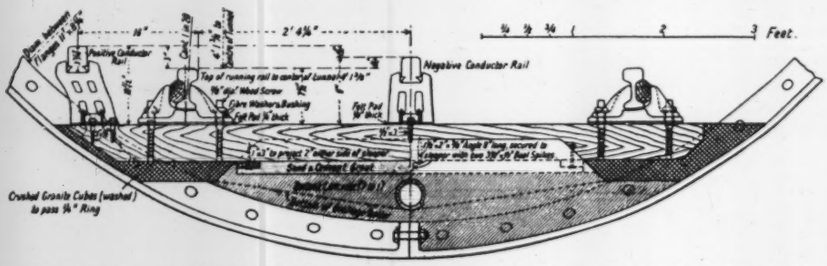


FIG. 9. TRACK CONSTRUCTION OF THE BAKER ST. & WATERLOO RY.; LONDON, ENGLAND.

CITY STREET RAILWAY SUBWAY.—A simpler and more promising type of track construction has been adopted in the shallow subway line built by the London County Council to carry its street railway lines under a new street in the heart of the city. This is shown in Fig. 10, and it will be seen that it is in combination with the conduit system for electric traction, this system being used on all the city surface lines. The subway is used only by double-truck electric street cars running on a one-minute headway. The track is laid with 105-lb. 7-in. grooved girder rails, 45 ft. long, resting on longitudinal pitch-pine timbers 12 × 6 ins., to which they are secured by ¾-in. bolts and clamps at intervals of 7 ft. 6 ins. No ballast is used, but each line of timbers is laid in a channel in the concrete foundation or floor and grouted in with a 3 to 1 Portland cement grouting. The rails are laid with square supported joints, having 24-in. splice bars with six 1-in. bolts; the joints rest on ⅝-in. steel base plates, 12 × 24 ins., secured to the timbers by screws. A concrete filling is packed around the rails, the heads of which are flush with the floor. At the joints of the longitudinals the timbers are halved together and have steel straps on top which extend beyond the timbers and carry ⅞ × 15-in. bolts whose heads are fitted to anchor plates embedded in the concrete. A similar anchor is used at the middle of each longitudinal. Where the line runs in a pair of single-track circular tunnels for a short distance, flat tie-bars with 1-in. threaded ends are passed through the webs of the rails and through plates in the sides of the conduit.

The two underground stations are about 1,200 ft. apart, and ventilating openings 2 ft. diameter are left in the roof at intervals of 200 to 300 ft. As regards drainage, sumps are provided at the low points of the grades; from these the water is pumped by electric pumps having automatic starting switches and discharging into a pit in the roadway which is connected with the sewer. This line was opened in February, and no observations as to the temperature or the state of the air have yet been made. It was designed by Mr. Maurice Fitzmaurice, M. Inst. C. E., Chief Engineer of the London Council, and was built under his direction. It was described and illustrated in our issue of July 12.

LIVERPOOL, ENGLAND.

MERSEY RY.—This is a double-track, brick-arched tunnel line, built under the Mersey River for local service between Liverpool and Birkenhead. The tunnel is 26 ft. wide, or 50 ft. 6 ins. at stations. The railway was originally operated by steam locomotives, but has been converted to electric traction. The track is of ordinary construction, but with the addition of a positive collector rail on the inner ends of the ties, and a negative return rail on the middle of the ties; both these rails are of tee section. The track rails are of the English bull-head section, weighing 86 lbs. per yd. and carried in cast-iron chairs on the ties, being secured in the chairs by wooden keys. The rails are laid with square suspended joints, spliced with 18½-in. bars and four bolts. The ties are 5 × 10 ins., 9 ft. long, spaced 2 ft. 4 ins. c. to c., and laid in cinder ballast with a minimum depth of 9 ins. under the ties. The stations are about ¾ mile apart. The trains are handled by 35-ton, double-truck motor cars, and there are about 374 trains daily in each direction. A drainage heading 8 ft. diameter is built beneath the tunnel, with a vertical pump shaft on each shore. There are also 7-ft. inclined ventilation headings, with connections to the tunnel and four shafts at the stations. Mr. J. Shaw is Resident Engineer.

PARIS, FRANCE.

METROPOLITAN RY.—The Metropolitan Ry. Co., of Paris, has adopted for all its lines the ordinary system of track construction, using tee rails of 104 lbs. per yd., with 24-in. four-bolt and 32-in. six-bolt splice bars; in some cases the joints are square and supported, in others they are suspended, and in still others the joints are broken only by the space between two ties. The ties are 8 × 5½ ins., 7.2 ft. long, except that those carrying the conductor rail are 8.2 ft. long; they are spaced 32 ins. c. to c. on grades and 38 ins. on the level. The ballast is of broken stone, about 14 ins. deep under the middle of the tie. No electric locomotives are used, but only motor and trail cars. The four-wheel motor cars weigh about 10 tons and the double-truck motor cars about 28 tons. The line was described in our issue of Dec. 6, 1900.

The stations are from 1,430 to 2,000 ft. apart, and some of them have ventilating openings. Drainage is collected at low points, and either flows directly to the sewers or is pumped by hand or electric pumps when the sewers are above the level of the sumps. The drainage of the track is perfect, but the drainage of water entering the upper part of the tunnel leaves much to be desired, and it is found very difficult to obtain a water-tight masonry construction. The temperature is nearly always higher than that of the exterior air and varies from 59° to 74° F. There is no unpleasant odor, except that on one line using creosoted ties the smell of creosote is quite strong. The noise of trains is quite marked, and varies with the tunnel section, the ballast, the alinement and the rolling stock. To reduce the noise, all new lines will have sand ballast and cars mounted on trucks. The number of trains each way per day ranges from 253 to 328, the trains having from four to seven cars.

PARIS & ORLEANS RY.—The underground extension of this trunk line to its new terminal station for main-line steam trains and suburban electric trains has the ordinary type of track. The 85-lb. double-head rails, 44 ft. long, are carried in 40-lb. chairs, and laid with square suspended joints, spliced with 18-in. bars and four bolts. The chairs are secured by screw spikes to ties 8 ft. 6 ins. long, 21 ties to a rail length. The ballast is of gravel, 6 to 8 ins. thick under the ties. The line is operated by 50-ton electric locomotives, 55-ton motor baggage cars, and combined motor passenger and baggage cars, all mounted on four-wheel trucks. The stations are about 1¼ miles apart. The tunnel is ventilated by openings overlooking the quay along the river Seine, and drainage water is led to three low points and pumped by electric pumps having automatic starting switches. Owing to the number of openings, the temperature and condition of the air in the tunnel is about the same as outside. The traffic is about 100 trains per day in each direction. The railway was described in our issues of Aug. 18, 1904, and Feb. 23, 1905.

BUDAPEST, HUNGARY.

FRANZ-JOSEF RY.—The electric underground railway at Budapest has a double-track tunnel of rectangular section, with concrete floor and walls, and a roof of transverse I-beams with concrete arches. A row of columns between the tracks supports two lines of I-beams forming an intermediate support for the roof beams. The width is 19.68 ft. and the clear headway 9 ft., while the street paving is laid on a shallow bed of filling directly above the roof. The track is laid with tee rails 4.6 ins. high, on steel trough ties embedded in gravel ballast. (Engineering News, March 21, 1895.)

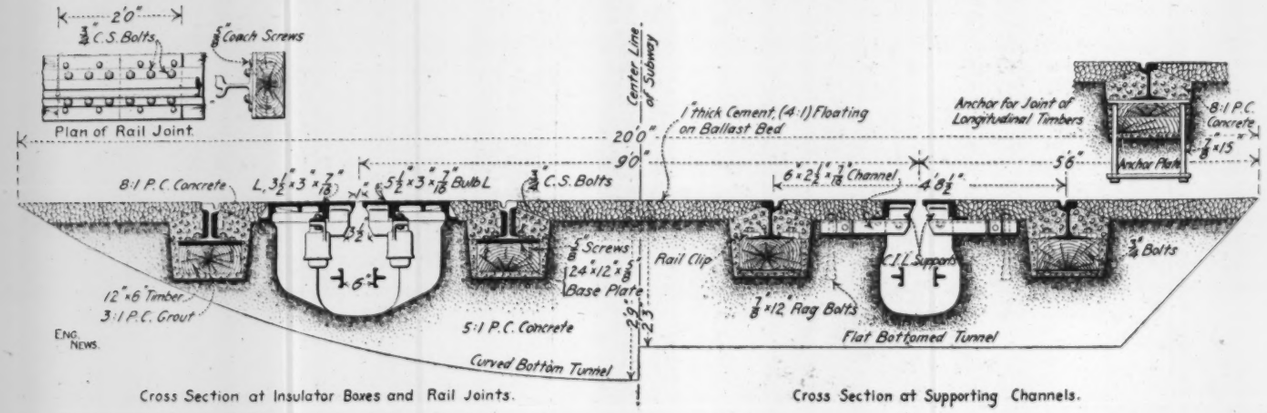


FIG. 10. TRACK CONSTRUCTION IN THE STREET RAILWAY SUBWAY UNDER KINGSWAY; LONDON, ENGLAND.

EXTENSION RIBS AND JACKS FOR CAISSONS AND TRENCHES.

The accompanying cuts represent a braced caisson system devised for sinking foundation or other wells, shafts, etc., in soft material which is subjected to heavy pressure, such as that due to adjacent buildings. In the construction of the deep concrete piers now almost universally adopted for the foundations of large buildings in the business district of Chicago, the wells are excavated in the clay in depths or lifts of 3 to 5 ft., each lift as completed being lined with vertical wooden staves. The lining is usually braced on the inside by steel hoops, each formed of two semicircular sections of steel bars on edge, having the ends bent inward to give a bearing for the two sections forming a hoop. These are sometimes difficult to adjust properly, and if the shaft is made a little larger than the final diameter to admit of placing these circular braces, the ultimate closing together under pressure may result in a movement of the clay body sufficient to cause settlement or cracking of adjacent buildings. This would be specially dangerous where large buildings with shallow foundations are likely to be affected, and in some cases, therefore, the shaft bracing has consisted of horizontal side timbers or frames with pairs of jacks placed diametrically across the shaft.

Owing to the disturbance of the soil by the construction of the Chicago telephone tunnels, the southwest corner of Marshall Field & Co.'s wholesale house at the southeast corner of Quincy and Franklin Sts. settled some months ago to such an extent as to cause large cracks in the building (Engineering News, Oct. 5, 1905). It will therefore be necessary to build new foundations under this corner of the building, and to carry them down to rock or hardpan. This work will be undertaken by Mr. Geo. W. Jackson, as Chief Engineer of the Illinois Tunnel Construction Co., and the method of bracing the caissons described below was first devised by him for this work, in view of the enormous pressure or load to which the caissons will be subjected while the foundation wells are being sunk.

It will be seen from the sections in Fig. 1 that each brace is formed by four pieces of 4-in. steel tee bars, bent to form a circular sectional rib, and by a central steel hub or drum of octagonal or other form, to which are attached jack screws whose heads are fitted to shoes on the horizontal web of the circular rib. The usual form of vertical plank sheathing is employed. The jacks can be set up to such an extent as to forcibly compress the surrounding material, and in this way prevent any slipping of the material or any inward bulging of the caisson, either of which would be serious as affecting the safety of the construction work and of the building itself or adjacent structures. In filling the finished well with concrete, also, each rib can be readily slackened and shifted upward, maintaining the pressure close to the surface of the concrete. If necessary, of course, the jacks and ribs can be left in place. The jacks can be used for caissons of various diameters, the ribs being simply slipped into the bearing shoes, and the ribs can be extended to form a bell-mouth or conical chamber at the bottom of the well, as is generally done to give additional bearing area where the foundation is upon hardpan and not upon solid rock.

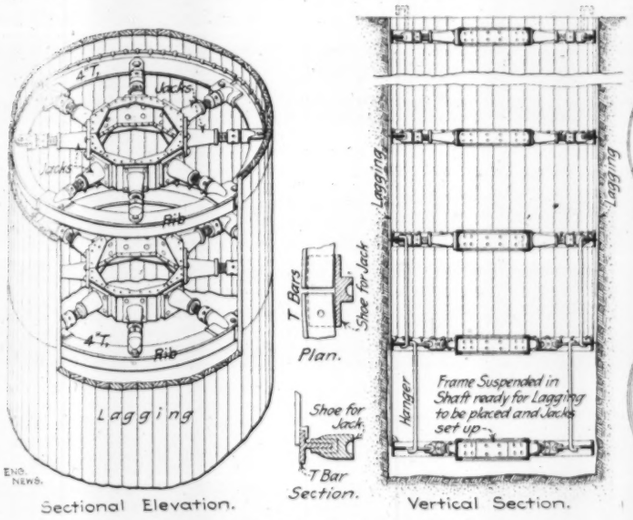


FIG. 1. EXTENSION RIBS OR BRACES FOR SHAFTS.
Geo. W. Jackson, Chicago, Designer.

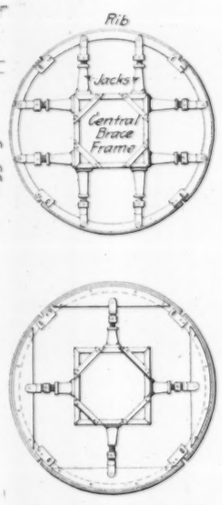


Fig. 2. Alternative Designs for Extension Ribs.

In Fig. 2 are shown alternative arrangements of the ribs and jacks. These can also be adapted to trench excavation, the rectangular timber ribs being in contact if necessary, so as to form a continuous bracing. For information and drawings we are indebted to the designer, Mr. George W. Jackson, consulting and contracting engineer, 177 E. Monroe St., Chicago.

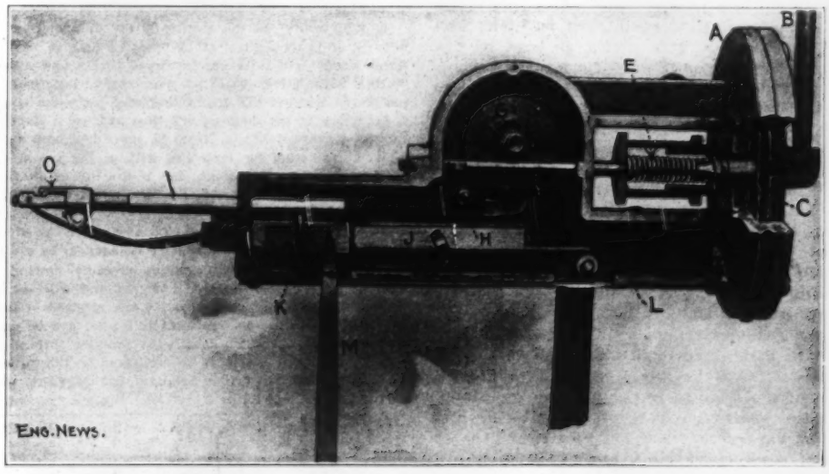
A CONTINUOUS HORSE-POWER INDICATOR FOR STEAM ENGINES.

An indicator which is permanently attached to an engine and shows continuously the horse-power developed is a device which is now being introduced and which should prove a valuable auxiliary in the proper and economical handling of an engine or power plant. It is adaptable to any type of steam engine, and to air compressors, etc. Its design is based upon the principle that the horse-power is the function of (1) the speed of the piston, and (2) the difference between the mean steam and back pressures in the cylinder.

The construction is shown in the accompanying cut. The diaphragm chamber, A, has one side connected to the steam pipe or valve chest by the pipe B, while the other side has a pipe connected to the exhaust pipe of the engine. The diaphragm C therefore moves according to the varying differences in steam and exhaust pressures, and operates the rod D, which is held against it by the spiral spring at E. A rack on the upper side of the rod operates a multiplying gear, the rack engaging with a pinion F, the shaft of which also carries the spur wheel G; this in turn engages the intermediate wheel H, which gears with the rack on the bar J. This bar has a graduated scale K, which is thus shifted to and fro as the pressures vary, the tail spring L taking up any lost motion. The arm M (with its end forming a pointer traveling over the scale K) is attached to a part of the valve gear or governor mechanism which has a movement varying with the speed of the engine and the point of cut-off, such as the governor rod of a Corliss engine. Thus with the movements of the scale K and the pointer M in combination, the pointer will continuously indicate on the scale the horse-power developed in the engine cylinder.

When the indicator has been set in place, it is calibrated by means of an ordinary steam indicator, the scale being then suitably graduated in horse-power. Adjustments are made by the screw sleeve regulating the tension of the spring at E. The device can also be used as an overload alarm, by attaching an electric contact to the scale, as at N. Should the engine then be loaded beyond a predetermined overload limit, or should it start to race, the contact point N on the scale will strike the pointer M; this makes a contact at O, causing an electric bell to ring. This device, which is already in use, is the invention of Mr. John H. Shreffler, and is being manufactured by the Shreffler Engine Indicator Co., 376 South Campbell Ave., Chicago, Ill.

A TRAIN ANNUNCIATOR FOR SIGNAL CABINS at interlocking plants for grade crossings and junctions has been introduced, the special purpose of which is to notify the signalman of the approach of a train. The signals are normally at danger, and the engineman whistles to notify the signalman. If the signal is not lowered promptly, owing to the failure of the signalman to hear the whistle or to locate the track on which the train is approaching, the train may have to slow down or stop when it might have run through without a check. With the annunciator apparatus in service, relays are located at any desired distance from the signal cabin, and as the train passes it causes an indicator to be displayed and an electric bell or buzzer sounded, calling the attention of the signalman. At important points the annunciator may be arranged on the closed circuit system, so that the signalman will be notified in case of the failure of a live wire, battery, etc. The annunciator is made by the Railroad Supply Co., of Chicago.



A CONTINUOUS HORSE-POWER INDICATOR FOR STEAM ENGINES.
Shreffler Engine Indicator Co., Chicago, Makers.

A METHOD OF MIXING AND LAYING BITUMINOUS CONCRETE FOR MILL FLOORS.

By C. H. Chadsey.*

With the advent of tar concrete, in response to the demand for a material which would make a substantial and moisture proof base for wood covered mill floors, has come a new phase of the concrete business. Apparently very few floors have been made of this material; there is certainly a lack of information as regards the method of fabrication. The writer, upon whom devolved the task of laying over 2,000 sq. yds. of this floor, could learn of no other method having been used than hand mixing and no other

FURNACE FOR HEATING SAND, BROKEN STONE AND TAR FOR BITUMINOUS CONCRETE.

aggregates than steam cinders, with the tar as a binder. It being almost impossible to secure either steam cinders or gravel except at excessive cost, it was decided to use crushed stone and sand, since these could be had quite readily and at reasonable expense.

Conversations with the agents for two of the most popular concrete mixing machines brought out the information that neither had even heard of his machine, or any other, having been used for mixing bituminous concrete. In order to avoid the disagreeable features of hand mixing, suffocating fumes, hard labor and inferior product, and at the same time to expedite the work the writer devised the simple plant herewith illustrated.

Two 8-in. brick walls about 2 ft. 6 ins. high, 4 ft. apart and about 26 ft. long, terminating in a smoke flue, comprised the furnace. On top of this was set at one end the tar melting tank, about 4 × 6 × 2 ft. deep, then sheet iron plates 4 × 8 ft. for heating sand, then half-inch iron rods made into a grid, giving an area of 4 × 8 ft. for heating the crushed stone. A fire made from barrel staves and refuse wood piled beneath the tar tank was sufficient for heating the tar, sand and stone. The grid was especially efficient, as the heat could come in direct contact with and circulate through the layer of stone. A small cleaning door at the ground allowed screenings to be raked out and mixed with the batch.

The success of the operation depends almost entirely upon keeping the materials piping hot from the time they leave the furnace till they are deposited in place.

A Ransome mixer, model 1906, was selected as the type best suited to this work for the reason that heat could be readily applied to the exterior of the drum by means of a wood fire built beneath. This proved quite effective in preventing the concrete from adhering to the blades, though occasionally the attendant would use a chisel bar if the aggregate had not been properly heated before being brought to the mixer. A little "dead oil" applied to the discharging scoop, as well as to the wheelbarrows, shovels and wooden stamps, effectually prevented any concrete from adhering to them.

The method for depositing was the same as for ordinary cement sidewalks or floors. Wood strips attached to stakes driven into the ground enabled the workmen to finish the concrete at the proper elevation. The mixture acquires its full strength and hardness after a few hours or as soon as it has cooled. The wearing surface in this case consisted of a layer of 2-in. planks covered by matched hardwood flooring laid diagonally. The principal feature about this was the method of fastening the 2-in. planks. Hot pitch to the depth of about ¼-in. was poured upon the concrete floor and the planks immediately pressed thereon, the last plank laid being toe-nailed to the proceeding one just enough to keep the edges even. After a few minutes the plank would adhere so firmly that its removal was very difficult. The hardwood surface was put on in the usual manner.

The special advantage of this construction lies in its solidity and durability. The decaying of ordinary floors, which requires their renewal every five or six years, is here eliminated, since no moisture can attack the floor from beneath. Its permanency should, therefore, depend upon the wearing qualities of the hardwood surface. Its solidity is such that any ordinary machinery can be set without the necessity of special foundations, thereby cheapening the cost of installation as well as allowing subsequent additions or alterations as convenience may require.

*Construction Engineer, Northern Aluminum Co., Ltd., Shawinigan Falls, P. Q., Canada.

COMPARATIVE VALUE OF TIES OF DIFFERENT MATERIALS.*

By W. C. Cushing.†

Having been approached from time to time by the inventors of different designs of concrete and steel cross-ties, the writer found it necessary to make an investigation, with a view to determining, as closely as possible, the relative value of such cross-ties, taking cost and prospective life into account, as compared with the wooden cross-ties at present in use. The article by Mr. S. Whinery in the "Railroad Gazette" for Nov. 11, 1904, furnished the best plan for this study, and tables of cost have been derived from Mr. Whinery's formulas. In connection with the tables, the following deductions are presented:

(1) With white oak ties costing 70 cts. delivered on the railway, it is economical at the present time to buy inferior woods at a price not to exceed 50 cts., have them treated with zinc-chloride or zinc-tannin, lay them in the tracks without the use of tie-plates (except where it is necessary to use them on oak ties) and use a standard railway spike. A life of 10 or 11 years has been found to be a maximum for such ties without the use of tie-plates and better fastenings, and if the life of 10 years is not attained, there will be that much loss to the company.

(2) When a white oak tie reaches a cost of 86 or 87 cts. delivered on the railway, it will be economical to use the zinc-creosote process, or straight creosote costing 35 cts., if the tie costs 46 cts. delivered and will last 16 years; or, it will be economical to use straight creosoting costing 85 cts. for treatment if the tie can be made to last 30 years, which is French practice, before the oak tie reaches a cost of 80 cts. delivered on the railway. In both of these cases, it is assumed that tie-plates, wood screws and helical linings‡ are used because ties cannot be made to last more than 10 or 12 years without the use of proper fastenings, since, otherwise, the ties will be destroyed by mechanical wear. It is necessary, therefore, to use improved fastenings when we expect to obtain a life of ties greater than 10 or 11 years. It will also be economical to use a steel tie costing 75 cts. delivered, if it will last 20 years.

(3) When the white oak tie reaches a cost of 70 cts. delivered on the railway, it will be economical to use either ties of inferior woods treated with zinc-tannin if a life of 14 years can be obtained, the improved fastenings being used; or a concrete tie costing $1.50 will last 20 years.

(4) When the price of white oak ties reaches 80 cts. it will be economical to use a steel tie costing $2.50 which will last 30 years, a concrete tie costing $2.25 if it will last 30 years, or an inferior wood tie treated with zinc-chloride if a life of 12 years can be obtained.

(5) With ties of inferior woods costing 46 cts. delivered on the railway we must obtain a life of from 18 to 20 years, whether treated with zinc-chloride, zinc-tannin or zinc-creosote, to make them as economical as white oak ties costing 70 cts. It is assumed, of course, that they must have the most approved fastenings in order to attain an age as great as that.

(6) With inferior woods costing 46 cts. delivered, and if the creosoting costs 30 cts., it will be necessary for us to obtain a life of 21 years in order to make them as economical as white oak ties costing 70 cts. delivered.

(7) With inferior wood ties costing 46 cts. delivered, and with the creosote treatment costing 85 cts., as in French practice, it will be necessary for us to obtain a life of 36 years from the ties in order to make them as economical as white oak ties costing 70 cts. delivered.

(8) With steel ties costing $1.75 each delivered, it will be necessary for us to obtain a life of 28½ years in order to have them as economical as white oak ties costing 70 cts. delivered. This price is a little less than the cost of the Buehrer steel ties.

(9) With concrete ties costing $1.50 each delivered, it will be necessary for them to last 28 years before they will be as economical as the white oak ties costing 70 cts. delivered.

(10) With steel ties costing $2.50 delivered and concrete ties costing $2.25 delivered, which are approximately the prices of the Seitz steel tie and the Buehrer concrete tie, it is necessary for them to last over 50 years each in order to make them as economical as the white oak ties costing 70 cts. delivered.

(11) In order to make treated inferior woods as economical as white oak costing 70 cts. delivered, when the treated ties are equipped with proper fastenings in order to make them last as long as has been found practicable by experience, we can only afford to pay for the ties delivered on the railway, 10 cts. each when treated with zinc-chloride; 20 cts. each when treated with zinc-tannin, or creosote at 30 cts.; 23 cts. each when treated with zinc-creosote, and 29 cts. each when creosoted in accordance with French practice.

(12) In order to make them as economical as white oak ties costing 70 cts. delivered, we can only afford to pay $[illegible] each for steel ties which last 20 years, and $1.71 [illegible] lasting 30 years.

(13) In order to make them as economical as white oak ties costing 70 cts. delivered, we can only afford to pay as first cost of concrete ties delivered, $1.15 each, if they last 20 years, and $1.57 each if they last 30 years.

(14) We know nothing about the life of concrete ties, and it is at least very desirable to experiment with them for yard and side tracks even though we do not use them in the main tracks, because they might lie undisturbed in yard tracks for many more years than they would in main tracks.

(15) When white oak ties are costing 70 cts. delivered (about present prices), we can afford to buy inferior oak and other hard woods at 45 cts. to 50 cts. (present prices), and have them treated with the zinc-tannin or zinc-chloride processes, and only use common spike fastenings.

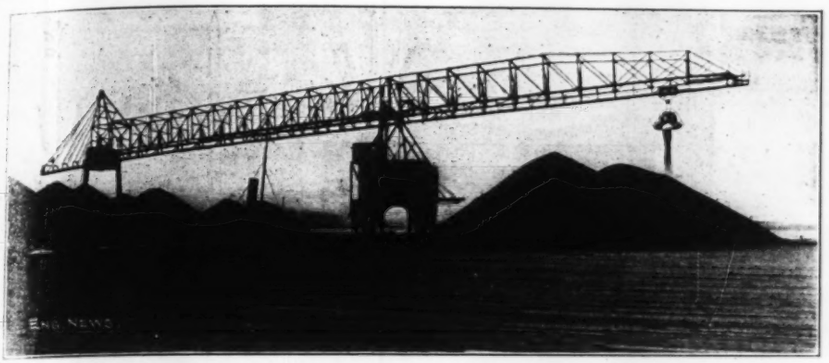
*Abstract of a paper published in Bulletin No. 75 of the American Railway Engineering & Maintenance of Way Association, Chicago.

†Chief Engineer of Maintenance of Way, Pennsylvania Lines West of Pittsburg (Southwest System), Pittsburg, Pa.

‡Illustrated and described in Engineering News, June 21, 1906.

COAL HANDLING AND SCREENING PLANT AT DULUTH, MINN., FOR THE BOSTON COAL DOCK & WHARF COMPANY.

The coal and ore handling equipment at ports on the Great Lakes has reached a high degree of development, and the accompanying cut represents one of two large coal-handling machines, which are also equipped with screening plants, and have been recently installed on the dock or pier of the Boston Coal Dock & Wharf Co. at Duluth, Minn. The buckets of the machines unload coal from steamers or barges and store it on the stock piles; they also deliver coal from the stock piles to the screening equipment carried in the tower of each machine, and finally deposit the screened coal in box cars and the stock coal on storage piles. The conveyor has a bridge 300 ft. long, of which 130 ft. is a cantilever span, the



COAL HANDLING AND SCREENING PLANT FOR THE BOSTON COAL DOCK & WHARF CO., DULUTH, MINN.
Wellman-Seaver-Morgan Co., Cleveland, Ohio, Builders.

span from the tower to the shear-leg support at the edge of the pier being 176 ft. At the front end of the bridge is a 53-ft. hinged cantilever which projects over the vessel or can be swung up to clear the masts and rigging of vessels as they approach or leave the pier. The machines handle 2-ton Hulett patent excavating buckets at speeds of 250 ft. per minute in hoisting, and 1,000 ft. per minute in traversing. The machines are self-propelling, and can travel along the dock at about 75 ft. per minute.

Steam power is used for all operations. One engine operates the bucket and moves the machine along the dock. A second engine operates the trolley running on the bridge, while a third engine operates the coal screen and slack-coal conveyor, which is shown projecting from the rear side of the tower. The screening chutes are provided with gates at the hopper, so that the flow of coal can be accurately controlled, and at the lower ends are telescopic folding chutes for discharging coal into box cars on the railway track in front of the tower. There are two operating cabins; one is over the shear legs and enables the operator to see the operations in the hold of the vessel; the other is on the tower and is used when handling the coal from the storage piles to the screen hoppers. The hinged cantilever is handled by cables on a drum driven from the engine which operates the bucket; this drum is fitted with a clutch and brake.

These machines were built by the Wellman-Seaver-Morgan Co., of Cleveland, Ohio, and we are indebted to the builders for photographs and information.

CUT OFF ON THE GREAT WESTERN RAILWAY, PLYMOUTH TO LONDON.

Railway improvements of main lines by means of cut-offs and diversions for the purpose of shortening time and distance for through trains are far less numerous in European countries than in the United States, owing to the very different conditions under which the main lines have been located. As a rule the European lines have been located to serve the large cities and to carry a heavy traffic from the beginning, and diversions between cities in these closely settled countries are not often warranted. Nevertheless, some important works of this kind are occasionally carried out, and a rather striking example has recently been completed in England by the Great Western Ry., for the improvement of its main route between London and Plymouth. The distance was 245.75 miles by this railway, as compared with 230 miles by the London & Southwestern Ry. With the adoption of Plymouth as a port of call by some of the transatlantic steamship lines there was naturally a great rivalry and competition between the two lines for the special as well as the regular passenger traffic, and the Great Western Ry. eventually established a new route reducing the distance to 225.75 miles. The change is between London and Exeter, both railways passing through the latter place. The distance was originally 193.75 miles by the Great Western Ry., as compared with 171.75 by the London & Southwestern Ry. The former had the disadvantages of some 1% grades and some long, sharp curves through large cities; the curves necessitated a material reduction in the speed of all fast trains, but in one case this trouble was eliminated by building a cut-off line through the outskirts of the city. The other railway, however, had the disadvantage of heavier grades over the western portion of its line. When the sharp competition began, the Great Western Ry. made the 193.75 miles to London in 3 hours 25 mins. (without a stop), and the London & Southwestern Ry. made the 171.75 miles in 3 hours 15 mins. By building new stretches of line to connect up portions of several branches and comparatively unimportant lines, the Great Western Ry. established a cut-off or diversion about 130 miles in length; this effected a saving of 20 miles in distance, besides obtaining more favorable grades, there being only a few short stretches of 1% grade. The fastest trains now make the run of 173.75 miles in 3 hours 3 mins. to 3 hours 8 mins., thus effecting a saving of several minutes and beating its competitor's schedule; for the 225.75 miles between London and Plymouth the time is 4 hours 10 mins. (without a stop). This includes allowance for a present reduction of speed over the new portions of the line, but when these are in condition for high-speed service a further reduction (to about 3 hours 50 mins.) is expected. Such a service, of course, means very high speeds maintained for considerable periods, and whether the recent disaster on the rival line will have any effect upon the train schedules must remain to be seen.

STEAM MOTOR CAR: CANADIAN PACIFIC RAILWAY.

While the modern development of railway motor cars in this country has been mainly in the direction of the use of gasoline engines (either direct or in combination with electric generators and motors), the Canadian Pacific Ry. in introducing this class of equipment has followed European practice in adopting the steam engine for the motive power. This railway has now one steam car in operation for suburban service between Montreal and Vaudreuil, 24 miles, and reports that it has so far found the car very satisfactory. For information respecting it we are indebted to Mr. H. H. Vaughan, Assistant to the Vice-President.

The steam car resembles a combination passenger and baggage car, as will be seen by the accompanying cut. The special feature is in the boiler, which is of the marine return-tubular type with a single Morison corrugated furnace. This railway is strongly in favor of the use of superheaters on locomotives, and the steam car is fitted with a superheater having 21 steel tubes 1¼ ins. diameter; this is of such capacity that when the steam reaches the valve chest it has a temperature of 700° to 750° F. The fuel used is crude oil, and is fed to the furnace by a slot burner of the Booth type, the supply cock and blower being controlled by an automatic device. The oil is carried in a tank of 2,000 lbs. capacity, which is built in the frames of the driving truck, and in which an air pressure of 15 lbs. is maintained constantly. The boiler is also fitted with a sand blowing device for cleaning soot out of the tubes. For the boiler feed, there are two Hancock injectors, and the water supply is carried in tanks secured to the underframe of the car body; their total capacity is 1,080 U. S. gallons.

The driving truck has frames of ⅞-in. steel plate, and has outside cylinders placed at the rear end of the frames, driving the front axle. The wheels are not coupled. Single-bar girders are used, placed above the piston rods, and the connecting rods are of I-section. The pistons are of cast iron, 3 ins. thick, and the wheels have cast steel centers. Owing to the position of the fuel tank between the frames and the limited space available inside the wheels, the Walschaert outside valve gear is used, and operates piston valves of the inside-admission type. The car is equipped with the Westinghouse automatic brake system, specially adapted to this class of service.

The general dimensions are as follows:

Wheels, driving (2)	3 ft. 6 ins.
Wheels, trailing of motor truck (2)	2 ft. 10 ins.
Wheels, trailing truck (4)	2 ft. 10 ins.
Journals, driving truck	8 × 12 ins.
Journals, trailing truck	5 × 9 ins.
Weight on driving axle	42,440 lbs.
On motor truck	82,880 lbs.
On trailing truck	53,740 lbs.
Total	136,620 lbs.
Cylinders	10 × 15 ins.
Furnace (corrugated flue), diameter inside	2 ft. 8 ins.
Boiler, return-tubular, diameter	4 ft. 6 ins.
Tubes; No., 95; length	7 ft. 11 ins.
Tubes, diameter	1¾ ins.
Heating surface; furnace	51 sq. ft.
Tubes	485 sq. ft.
Total	536 sq. ft.
Superheating surface	62 sq. ft.
Steam pressure	180 lbs.

FIRE-KILLED TIMBER is sometimes considered to be practically valueless, but it has been used for some years for railway ties and mine timbers, and with satisfactory results. According to investigations made in Colorado by the U. S. Forestry Bureau, the ties are as durable as those of green timber, hold spikes well and do not cut under the tie-plates. Some of the ties are from timber burned 35 or 50 years ago. Red fir is preferred; then yellow pine, limber pine and range pine, and even white pine is now used; spruce resists mechanical wear but needs a preservative treatment to make it resist decay. Such timber is also being used for making crates and boxes, the fire seasoning having driven out the odor of the pine so that it can be used for packing crackers. The timber is, of course, well seasoned, and it is expected that its utilization may be a source of profit to the forest reserves.

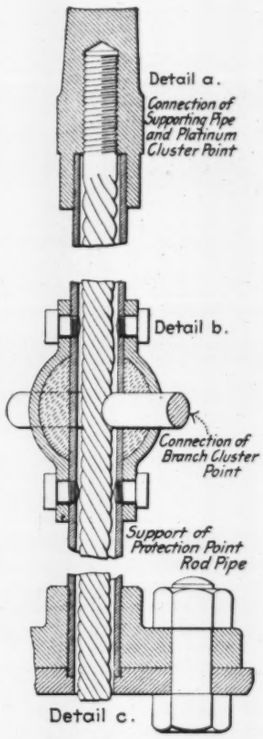
STEAM MOTOR CAR FOR SUBURBAN SERVICE; CANADIAN PACIFIC RY.

EXAMPLES OF THE PROTECTION OF CHIMNEYS AGAINST LIGHTNING.

That lightning conductors properly attached to buildings, chimneys, towers, etc., reduce, to a minimum, the liability of the structure being injured by lightning is, perhaps, best shown in the case of the Washington monument. This monument, which stands 555 ft. high in the center of a flat, well-watered country presents a very dangerous exposure to lightning. It was struck June 5, 1885, after which four copper conductors were run from its top into a pit which always contains at least 2 ft. 8 ins. of water, 15 ft. below the bottom of the masonry foundation. The four conductors are also connected to each other with copper rods and each is studded every 5 ft. of its length with lateral points 3 ins. long, gold plated and tipped with platinum. Since these conductors were placed on the monument it has suffered no damage, although the lightning plays around it every time there is a thunder storm, the latter being shown by cameras located at Ft. Meyer, the Capitol and elsewhere, which are constantly trained upon it.

Another example of the protection secured by the use of lightning conductors is the 250-ft. chimney of the Armour Packing Co., at Kansas City, Kan., which was struck by lightning and damaged to the extent of $7,000. After the chimney had been rebuilt it was protected with copper lightning conductors and platinum points, and has since suffered no damage.

Fig. 1. Lightning Indicater and Signal.


Detail a.
Connection of Supporting Pipe and Platinum Cluster Point
Detail b.
Connection of Branch Cluster Point
Support of Protection Point Rod Pipe
Detail c.

The importance of good lightning conductors is also shown by the fact that the U. S. Weather Bureau, after careful study, strongly recommends their use. Moreover, the National Fire Protection Association, at its last annual meeting, adopted a set of specifications for the protection of buildings against lightning (Engineering News, May 24, 1906) in which they recommend their use.

The indicator shown in Fig. 1 is an instrument for recording lightning strokes while at the same time an electric bell located in the house or elsewhere is rung when a discharge occurs. If the discharge is a cold stroke the needle will swing to the left; if a hot stroke to the right where it remains until reset. Furthermore by using a common dry battery the system may be tested at any time to see if it is in perfect working order. If, after making the proper connections, the needle swings around on the face of the indicator, it is a sign that the rods are in good conductive order; but if the needle remains stationary the rods are defective and the system should be carefully examined and repaired.

Fig. 2 shows the arrangement of lightning conductors on the 300-ft. brick chimney of the Nichols Copper Co., Laurel Hill, Long Island, N. Y., while Fig. 3 shows the arrangement of conductors used to protect the chimneys at the 58th and 74th St. power-houses of the Interborough Rapid Transit Co. of New York City. The vertical conductors are one-piece stranded copper wires, while the horizontal connection between these conductors is of the same material securely fastened thereto. The anchors are of cast copper and bronze alloy, which insures non-insulation of the line from the chimney and long life. Style "B" is used in brick chimneys for holding horizontal, and style "C" vertical conductors, while style "A," Fig. 5, is designed for reinforced concrete chimneys. The air terminals are all platinum tipped and supported with style "C" or "A" fasteners.

Fig. 4 shows details and general arrangement of air terminals placed on top of steel towers, designed for the protection of the oil tanks of the Standard Oil Co.'s plant at Sugar Creek, Mo. Detail "a" shows the manner of connecting the copper conductor with the top air cluster terminal and supporting pipe, "b" the connection of branch air cluster terminals to supporting pipe, "c" the attachment of the supporting pipe to the steel tower, "d" the top, platinum, cluster

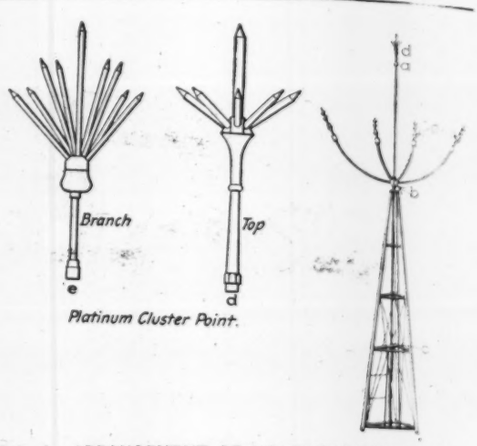


FIG. 4. ARRANGEMENT OF LIGHTNING CONDUCTORS ON STEEL TOWERS FOR THE PROTECTION OF OIL TANKS.

point and "e" the branch, platinum, cluster points. These towers are to be distributed among the oil tanks so as to give ample protection.

The lightning conductors here described were designed and installed by Carl Bajohr, 4051 to 4057 Keokuk St., St. Louis, Mo.

ADDITIONAL WATER SUPPLY FOR JOHANNESBURG, SOUTH AFRICA.

The City of Johannesburg is situated on the top of a mountain at an elevation of about 5,700 ft. above the sea level, and, excepting on the west, the ground falls rapidly to a lower level. North of the town the streams flow to the Indian Ocean, those south of it to the Atlantic. The geological formations in the vicinity consist of beds of quartzite, conglomerate and shale, which form a ridge about seven miles wide, running east and west. These beds dip sharply to the south, and are overlaid by a mass of diabase, which forms the Klip Rivesberg range. South of this range there is a considerable area of dolomite, extending along the valley of the Klip River.

The properties acquired by the Rand Water Board consist of the large freehold dam of Zwaartkopjes, extending for about five miles along the valley of the Klip River, north of the Klip River station, and water rights on other farms higher up the valley, extending a distance of about eight miles above Zwaartkopjes. It is this property that is being developed for the new water supply, although the Board acquired, at the same time, the property of the Johannesburg Water-Works Co. and the water supply works owned by the Braamfontein Co.

WATER SUPPLY.

The total catchment area draining to the Board's property on the Zwaartkopjes amounts to about 235 sq. miles, a rough estimate of the average rainfall being about 28 ins. per annum. The catchment has the peculiarity that much of the water that runs off the diabase and Witwatersand formation on to the dolomite is ultimately absorbed by the latter. The quantity of water which flows in the Klip River at the northern end of the farm Zwaartkopjes exceeds, by about 5,000,000 gals. daily, the amount which flows off from it, and as the difference is too great to be accounted for by evaporation, it is fairly certain that, on this farm, a large quantity of water finds its way underground. There is, therefore, but little doubt that the underground storage in the dolomite is large enough to equalize the fluctuations in the yearly supply which may arise from variations in the annual rainfall.

The Board has limited the quantity of water to be taken from these new and old sources to 10,000,000 gals. daily, and, as 2,000,000 gals. are now being pumped from the old wells at Zuurbekom, the property obtained from the Johan-

nesburg Water-Works Co., lying about eight miles above Zwaartkopjes, this leaves 8,000,000 gals., which it is expected can all be obtained from the Klip River properties of the Board, and therefore no steps are being taken to develop the remaining sources.

THE WELLS.

The manner of obtaining the underground water is to sink an 18-in. bored well to a depth below the surface varying from 140 to 220 ft. In order to shake and open the ground, in case the bore should have struck a fissure in the dolomite, a 9-in. hole is put down to a depth of 20 ft. below each 18-in. bore, and a charge of about 120 lbs. of blasting gelatine fired therein. The result of this is to shake the ground for a considerable distance around the bottom of the hole, thus connecting the well with any fissures that may happen to be in its vicinity. Experience has shown that this treatment produces a large increase in the yield of water. Wells are being sunk at ten different sites, a pair of holes being drilled at each site, in order to improve the chances of obtaining a large water supply as well as to enable the pump in one shaft to balance that in its neighbor, and to obviate fluctuations of load due to variations in the level of the suction water.

Each pair of pumps will be driven by an electric motor from a central headgear. The motors will be three-phase, 25-cycle machines, either 50 or 75 B HP., according to the lift, and will be fed by an overhead transmission line from the central pumping station. The feed pumps, economizers, air compressors for replenishing air vessels, and the house service pump in the engine house will also be driven by electric motors, as well as the machine tools in the workshop.

PUMPING STATION.

The generating units will consist of three sets of 360 KW., three-phase, 25-cycle, 3,300-volt generators, driven by triple-expansion engines, while pumping units will consist of a triple-expansion Corliss engine, with Reidler pumps and four triple-expansion vertical inverted pumping engines with single-acting rams driven direct from off the cross-heads, each capable of raising 2,400,000 gals. of water per 24 hrs., against a total head of 960 ft. The boiler house will contain eight Babcock & Wilcox boilers, with superheaters and Green's economizers, generating steam at 180 lbs. gage pressure and delivering it, at 500° F., to the engine stop valves. The main flue is arranged with two smokestacks, one at each end of the building, so that any of the boilers may be laid off for repairs without stopping the pumps. Water for local purposes will be obtained from a 9-in. well, which has been sunk at the engine house, while supplies will be brought in on a railway siding which has been laid from the main line at a point about 3½ miles distant.

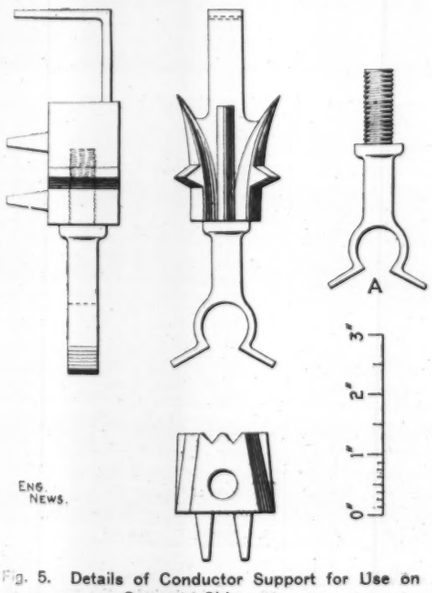


Fig. 5. Details of Conductor Support for Use on Concrete Chimneys.

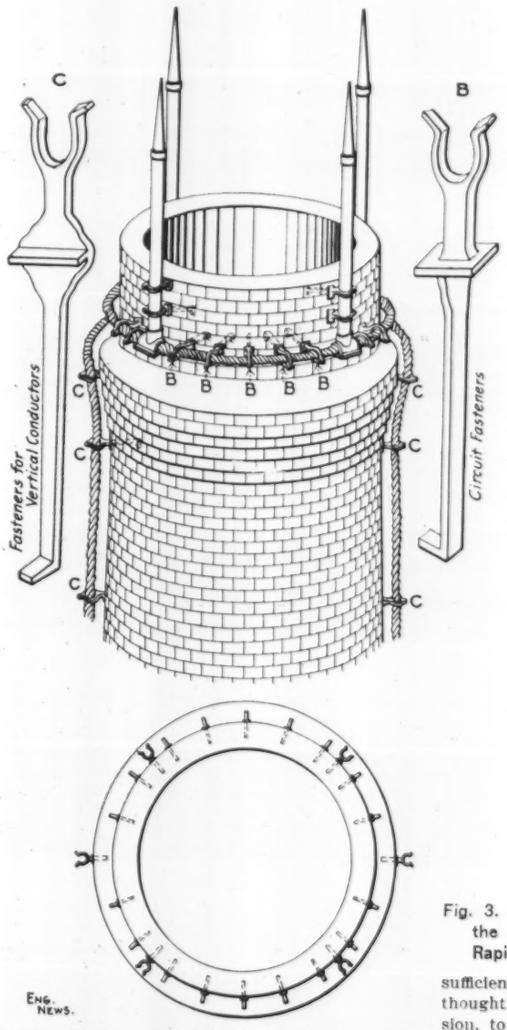


Fig. 2. Arrangement of Lightning Conductors on the Chimney of the Nichols Copper Co.

The motor-driven pumps at the well will raise the water to an elevation just sufficient to allow it to gravitate to the central pumping station. The pipe lines from the wells to the station will be for the most part of riveted steel plate, but, where conditions permit, concrete conduits will be used. These lines will terminate in two settling tanks, at the pumping station, each holding 650,000 gals., from which the water will pass into two clear water tanks, each having a capacity of 900,000 gals., where it will be drawn off by floating arms to the suction of the pumps. The settling and clear water tanks are in duplicate to allow of one pair being laid off for repairs.

The tanks, engine and boiler house are constructed of concrete, the walls of the tank, and the piers and arches of the buildings being reinforced with old wire rope, in order to avoid shrinkage cracks, and to reduce the volumes of concrete and cement used, the latter material being costly in the Transvaal.

PIPE LINES.

From the pumping station a 27-in. steel main 6¼ miles long has been laid northwards to the summit at Turffontein Nek, 810 ft. above the station, where there is a small reservoir, from which water gravitates to Village Main Reef. This pipe was acquired with the properties, and, although rather small for the volume of water to be carried, it was found to be more economical to raise the pressure than to buy new pipe. The pipes are of welded steel 7/16 in. thick, and, while of sufficient strength to carry the pressure, it was thought advisable, to make allowance for corrosion, to wrap about 10,000 ft. of the main, next to the lower end, with steel wire. No. 8, S. W. G. galvanized wire under an initial tension of 210 lbs. was wound on the pipe, the distance between each turn ranging from 1 in. to ½ in., according to the pressure to which the pipe is subjected. The wire as well as all pipe was dipped in a bituminous compound before using. This main is fitted with three non-return valves, necessary air valves, scorer valves and corrugated expansion lengths every 1,200 ft. with heavy Kimberly collars where these expansion joints occur. Elsewhere the pipes are provided with expanded single-riveted transverse joints, for the most part, riveted together, which forms an extremely rigid connection. All valve casings where the pressure exceeds 500 ft. of water are steel. The portion of this main near the summit, where the pressure is light, was laid with 29-in. riveted steel pipes. The covered reservoirs at Turffontein Nek and Village Main Reef hold, together, 2,660,000 gals. of water, which will serve to maintain the supply in case of temporary stoppage of the pumps.

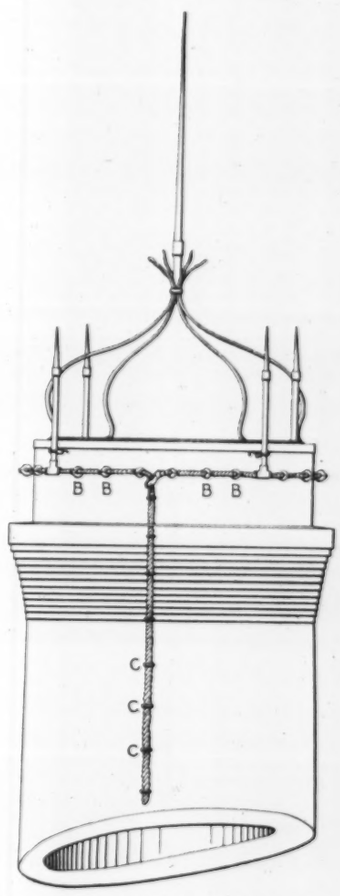


Fig. 3. Arrangement of Lightning Conductors on the Chimneys of the New York Interborough Rapid Transit Co.

A concrete reservoir is being built on the Simmer and Jack property, about 6½ miles distant and 120 ft. below the one at Village Main Reef, through which it will be supplied. Motor-driven pumps will be located here for supplying the mines at New Rietfontein and an existing 8-in. East Rand pipe line. These mains, as well as others, where there are no reservoirs, will be fitted with accumulators for automatically controlling the motors, thus keeping the pressure within certain limits.

The mains will be extended to Boksburg, lying east of Johannesburg, and to Roodepoort, or further if the demand requires it, and small balancing reservoirs will be built near Roodepoort and at Springs, each holding 210,000 gals. A

12-in. well has been sunk to a depth of 300 ft. at Springs with the idea that it will be adequate to supply the town of Springs and the railway. A small gas engine and producer will be used to drive the pumps, which will be capable of lifting 10,000 gals. per hr. Two 12-in. wells have also been put down at New Doornfontein to depths of 210 ft. and 170 ft., respectively, and the pumps will be operated by 25 B HP. single-phase electric motors, current being obtained from the municipality.

When these works have been completed it is intended to use the old pumping station at Paarlshoop, which receives its supply from the old well at Zuurbekom, to supply the West Rand, the mines south of Johannesburg, and, after the construction of a reservoir on Brixton Hill, a short distance north of Paarlskoop, to utilize the balance of the 2,000,000 gals., which is daily available at this station, to supply the north-western district of Johannesburg.

COST OF WORKS.

The estimated cost of the new works is £686,000 ($3,338,520), exclusive of the cost of land. It is expected that the plant will be entirely completed by June, 1908, and that by temporary arrangements a supply of 5,000,000 gals. daily may be obtained by October of the present year.

This scheme for obtaining an additional daily supply of 8,000,000 gals. was devised by Mr. D. Leitch, M. Inst. C. E., and Chief Engineer of the Rand Water Board, Johannesburg, Transvaal, to whom we are indebted for the information.

A TABLE OF WEIGHTS OF LACING FOR STEEL MEMBERS.

The subjoined table of weights of lacing will be found frequently useful in estimating steel-work. To compute the exact weight of lacing is just sufficiently involved to make most estimators prefer the practice of guessing at the proper allowance, a method which is generally justified by the unimportance of the lacing item in the total weight of a structure. The table here given saves the need for guessing [it is nearly always easier to take figures from a table than to guess at them], besides having the advantage of accuracy. The table was computed by Mr. Charles T. Lewis, of Chicago, Ill.

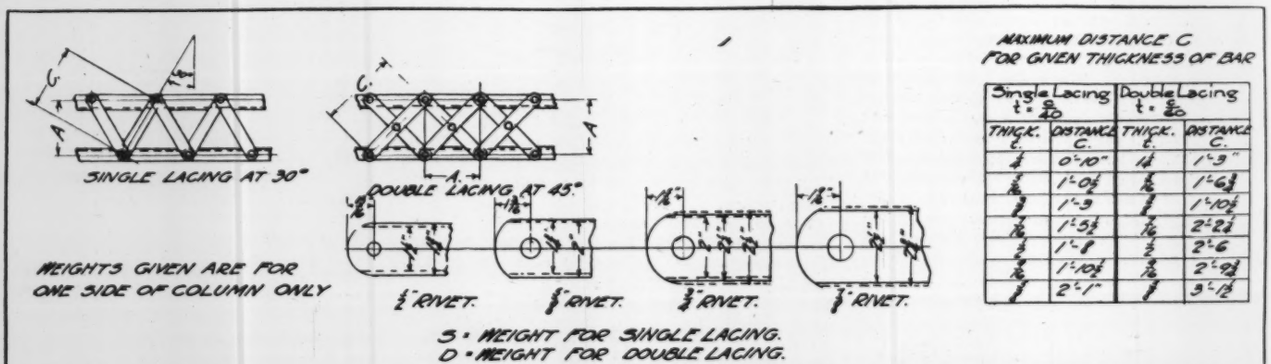
A WATER FILTRATION PLANT FOR NEWARK, Ohio, was made a condition of the approval, by the State Board of Health, some months ago, of plans for a new water supply for that city. Contracts having since been let for a power plant, mains, etc., but not for filters, the State Board of Health has secured an injunction against the use of the new supply for domestic purposes. The language of the injunction follows:

. . . . . That the defendants, the City of Newark, The Board of Public Service, The American Light & Water Company, be restrained and perpetually enjoined from introducing water through the pipes of said water-works system when completed for the purpose of public consumption or for any other purpose than fire protection, sprinkling, sewer flushing, and said parties hereinbefore named are each of them enjoined from making any connection between the water mains into which said new changed or extended water supply is introduced and any building, private or public, or from permitting the use of said water for any purpose other than extinguishing fire, sprinkling, flushing sewers until such time as the City of Newark shall build a filtration plant to the satisfaction and approval of the State Board of Health and until said State Board of Health has consented to the introduction of said new changed and extended water supply for the purposes other than fire, sprinkling and flushing sewers.

A LARGE HYDRAULIC OR SUCTION DREDGE for service in India has recently been built by Wm. Simons & Co., of Renfrew, Scotland, and is intended for inland work, cutting and improving irrigation canals and performing river improvement work. It will operate in shallow water and cut a channel 40 ft. wide. The steel hull is 250 ft long, 45 ft. beam and 18 ft. deep, while at the bow are two open wells 8 ft. 6 ins. wide and 36 ft. long. An adjustable frame or ladder in said well carries a main suction pipe, to the end of which are attached two suction heads, and in front of each head is a four-bladed rotary cutter of the Robinson system. There are also nozzles for water jets to loosen compacted sand which does not require the use of the cutters. Each pair of cutters is driven by spur and bevel gearing from a four-cylinder tandem compound engine. Instead of spuds, there are at the bow two high davits of plate girder construction with blocks and tackle for attachment to tubular mooring or anchor piles temporarily embedded in the bottom of the stream. The two centrifugal dredging pumps have a capacity of dredging 4,000 tons of sand per hour from a depth of 20 [illegible] and the sand can be delivered through a floating 42 [illegible] pipe line, 600 ft. long. This is supported by ten [illegible] ons and at the shore end is a larger pontoon with a [illegible] ow pipe raised to such a level as to be connected [illegible] a pipe discharging over the canal bank. Each [illegible] ing pump is driven by a vertical triple expansion en[illegible] of 900 HP. The dredge is self-propelling, being fit[illegible] with three four-bladed screws of small diameter, each [illegible] ven by a vertical compound engine; it can be driv[illegible] a speed of eight miles an hour.

A RACK-RAIL LOCOMOTIVE for the Manitou & [illegible] Peak Ry. has been built by the Baldwin Loc[illegible] Works. It differs from the earlier engines in [illegible] ing three driving pinions and usi[illegible] or fuel. The [illegible] has plate frames, carrying a [illegible] is set so to be horizontal on a grade of 16%. The Vauclain co[illegible] d system is used, with the low pressure above th[illegible] igh pressure cylinder on each side; the cylinders are [illegible] at an inclination of 16%, and the connecting rod at[illegible] tached to the upper end of a vertical working lever, [illegible] rom the lower end of which a return rod is led to the [illegible] rank on the front driving wheel. The wheels are couple[illegible] and the springs of the two rear pairs are equalized, [illegible] while weight is transmitted to the front wheels by [illegible] rubber springs on top of the boxes. The water tanks are at each side of the boiler, and oil is carried in two tanks under the cab, one on each side. Band brakes are provided on the first and second axles, and operated by steam and hand, respectively, although the latter can also be operated by an auxiliary steam cylinder if necessary. The Lechatelier brake, utilizing the main cylinders for braking in descending grades, is also used. The railway has the Abt rack system, and its maximum grade is 25%. The dimensions of the new engine are as follows:

Driving wheels (6), diameter	2 ft. 6 ins.
Driving pinions (3), diameter on pitch line	1 ft. 10 ins.
Wheelbase	10 ft. 2 ins.
Weight	60,000 lbs.
Cylinders, h. p. (2)	10 × 24 ins.
Cylinders, l. p. (2)	15 × 24 ins.
Boiler, diameter	3 ft. 8 ins.
Working steam pressure	210 lbs.
Fire-box	48 × 59½ ins.
Tubes, 176; diameter	1½ ins.
Tubes, length	8 ft. 6 ins.
Heating surface; tubes	540.7 sq. ft.
Heating surface; total	605.0 sq. ft.
Grate area	19.7 sq. ft.
Water	600 gallons
Oil (fuel)	325 gallons
Tractive power	25,284 lbs.



A in.	1½"-¼" S	1½"-¼" D	1½"-⅜" S	1½"-⅜" D	1½"-½" S	1½"-½" D	2"-¼" S	2"-¼" D	2"-⅜" S	2"-⅜" D	2"-½" S	2"-½" D	2½"-¼" S	2½"-¼" D	2½"-⅜" S	2½"-⅜" D	2½"-½" S	2½"-½" D	2½"-⅝" S	2½"-⅝" D	3"-¼" S	3"-¼" D	3"-⅜" S	3"-⅜" D	A ½
5	3.45	4.65	4.30	5.8	4.04	5.4	5.05	6.75	4.95	6.6	6.2	8.2	7.45	9.85	6.95	9.25	8.35	11.1		10.7		12.85		15.00		17.8		14.15			5
6	3.30	4.45	4.10	5.55	3.85	5.2	4.8	6.5	4.70	6.3	5.85	7.85	7.00	9.4	6.55	8.8	7.90	10.35	7.60	10.15	9.15	12.2	10.65	14.2	12.2	16.25	10.05	13.4	11.3		6
7	3.20	4.3	3.95	5.4	3.7	5.05	4.65	6.3	4.50	6.05	5.60	7.55	6.75	9.05	6.30	8.5	7.55	10.2	7.25	9.75	8.75	11.7	10.2	13.65	11.65	15.6	9.6	12.85	10.75		7
8	3.10	4.2	3.85	5.25	3.6	4.95	4.5	6.15	4.35	5.9	5.40	7.35	6.50	8.8	6.10	8.25	7.30	9.9	7.00	9.45	8.45	11.35	9.85	13.25	11.25	15.15	9.25	12.5	10.35		8
9	3.05	4.15	3.8	5.15	3.55	4.85	4.4	6.05	4.25	5.75	5.30	7.20	6.35	8.65	5.95	8.05	7.15	9.7	6.80	9.2	8.20	11.1	9.51	12.9	10.9	14.75	9.00	12.15	10.0		9
10	3.00	4.1	3.7	5.1	3.5	4.75	4.35	5.95	4.15	5.65	5.15	7.05	6.2	8.45	5.80	7.95	7.00	9.5	6.65	9.00	8.00	10.85	9.30	12.65	10.65	14.45	8.8	11.95	9.75		10
11	2.95	4.05	3.65	5.05	3.4	4.70	4.25	5.90	4.05	5.55	5.05	6.85	6.10	8.35	5.70	7.85	6.85	9.4	6.50	8.85	7.85	10.65	9.15	12.45	10.45	14.2	8.6	11.75	9.55		11
12	2.90	4.00	3.6	5.00	3.4	4.65	4.2	5.80	4.00	5.5	5.00	6.85	6.05	8.25	5.60	7.7	6.75	9.25	6.40	8.75	7.70	10.5	9.00	12.25	10.25	14.0	8.45	11.55	9.4		12
13	2.85	3.95	3.6	4.95	3.35	4.60	4.15	5.75	3.95	5.45	4.95	6.80	5.95	8.15	5.55	7.65	6.65	9.15	6.30	8.65	7.60	10.4	8.85	12.1	10.1	13.85	8.35	11.4	9.25		13
14	2.85	3.95	3.55	4.9	3.3	4.60	4.15	5.70	3.90	5.4	4.90	6.70	5.85	8.05	5.50	7.55	6.60	9.05	6.25	8.55	7.50	10.3	8.75	12.00	10.0	13.7	8.25	11.3	9.1		14
15	2.80	3.90	3.5	4.85	3.3	4.55	4.10	5.70	3.90	5.35	4.85	6.65	5.80	8.00	5.45	7.50	6.55	9.00	6.15	8.45	7.40	10.2	8.66	11.9	9.9	13.55	8.15	11.2	9.0		15
16	2.80	3.90	3.5	4.85	3.25	4.55	4.05	5.65	3.85	5.30	4.80	6.6	5.75	7.95	5.40	7.45	6.45	8.95	6.10	8.4	7.35	10.1	8.55	11.8	9.8	13.45	8.05	11.1	8.9		16
17	2.80	3.85	3.45	4.8	3.25	4.50	4.05	5.6	3.80	5.25	4.75	6.55	5.70	7.9	5.35	7.40	6.40	8.85	6.05	8.3	7.30	10.00	8.50	11.7	9.7	13.35	8.00	11.00	8.85		17
18	2.75	3.85	3.45	4.8	3.25	4.50	4.05	5.6	3.80	5.25	4.70	6.55	5.65	7.85	5.30	7.35	6.40	8.85	6.00	8.3	7.25	9.95	8.45	11.65	9.65	13.3	7.95	10.95	8.75		18
19	2.75	3.85	3.45	4.8	3.2	4.45	4.00	5.55	3.75	5.2	4.70	6.50	5.65	7.8	5.30	7.30	6.35	8.8	5.95	8.25	7.20	9.9	8.35	11.55	9.55	13.2	7.9	10.9	8.7		19
20	2.75	3.8	3.4	4.75	3.2	4.45	4.00	5.55	3.75	5.2	4.65	6.45	5.6	7.75	5.25	7.25	6.30	8.75	5.9	8.2	7.15	9.85	8.30	11.5	9.5	13.15	7.85	10.85	8.65		20
21		3.8		4.75		4.45		5.55		5.15		6.45		7.75		7.25		8.70	5.9	8.15	7.10	9.8	8.25	11.45	9.45	13.05	7.8	10.75	8.6		21
22		3.8		4.7		4.4		5.50		5.15		6.4		7.7		7.2		8.65	5.85	8.10	7.05	9.75	8.2	11.35	9.4	13.00	7.75	10.7	8.55		22
23		3.75		4.7		4.4		5.50		5.1		6.4		7.65		7.2		8.6	5.80	8.05	7.00	9.7	8.2	11.3	9.35	12.95	7.7	10.65	8.5		23

TABLE OF WEIGHTS OF LACING.—CHARLES T. LEWIS.

Weights are given in pounds per lineal foot of member laced, for single and double lacing, for *one side of member* only. The weight includes the wastage in cutting the lacing bars, but does not include rivets.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
WASHINGTON, D. C.: Home Life Building
ATLANTA: Austell Building
RUDOLF MOSSE, BERLIN AND HAMBURG, GERMANY

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When 4% 30-year municipal bonds secured by the credit of the largest and wealthiest city in the western hemisphere sell for an average of a trifle under 101 it is time for American cities to give careful attention to their present standing in the money market. We say this in the interests of prudence only, and not to sound a note of alarm. Every city should remember that there is a limit to the capacity of the municipal securities market in general and to the market for its own securities in particular. Every city should also remember that there is a limit to both the rate of interest and the total of interest-bearing obligations that its taxpayers will stand without vigorous protest. These facts demand carefully wrought municipal programs, to the end that the most pressing wants of each of the various city departments may be met year by year, and also that there may be a most careful development of all proper sources of municipal revenue, as well as due conservation of such revenues. Even after heavily discounting some of the rosy stories about the free flow of money into the treasuries of British city and loan treasuries, and the wise manner in which it is subsequently expended, we are still far behind our British cousins in both providing and spending our municipal funds. This may have no direct bearing upon the disappointing results in the recent New York City bond sale, but it can not fail to have an indirect influence upon all such sales, both in New York and elsewhere.

Few American cities appreciate the fact that proper railway terminal facilities are of more concern to the public than to the railways, and should therefore be a matter of most careful municipal concern. In view of this we were pleased to put on record, in our issue of July 26, an extended abstract of a report on terminal facilities at St. Louis, Mo., made by the Municipal Bridge and Terminals Commission of that city. The report is of far more than local interest, as it contains considerable information regarding terminal warehouses in other cities, besides a few valuable suggestions on the subject of municipal control of terminal facilities. Of no little engineering interest is the proposal, included in the report, for a third bridge across the Mississippi River, at an estimated cost of $8,000,000.

It might be argued that the railways may be trusted to work out their terminal facilities unaided and unhindered by the municipality, since they are so vitally interested in everything that will stimulate the movement of freight. But the first interest of the railways, as of other corporations and of individuals, is self-interest, and that is often blind. It is unnecessary, however, to justify municipal control or cooperation on any such grounds, since whenever and wherever two separate interests are involved, justice and the maximum benefit to each will come through counsel and cooperation, rather than through decision and action by one of the parties alone. Terminal facilities, as has already been said, and as is brought out clearly in the St. Louis report, deeply affect the general public, and, therefore, the public should have a say regarding their character, location and extent. The municipality, both as an organized body and as a conservor of the interests of the individuals whom it serves, is or should be the best representative of the public in the matter, but this does not preclude the cooperation or counsel of semi-public bodies, such as boards of trade. In conclusion, it should never be forgotten that terminal facilities, both freight and passenger, are or should be closely related to the street plan of a city, and do much towards making or marring its esthetic features.

The prevailing strong drift toward uniformity of practice in the technical details of any given industry, which finds expression in "standardization," is again illustrated by two documents which have reached us within a few days past. The one is a circular inquiry by a committee of the Railway Signal Association, on the subject of storage batteries for railway signaling. The other is a similar inquiry concerning brake-shoes for electric cars, on the part of the American Street & Interurban Railway Engineering Association, which has undertaken the task of standardizing brake-shoes, journals and journal-boxes, wheel treads and flanges, and rails. While the latter inquiry has the avowed object of leading to the formulation of a "standard," the investigation by the Railway Signal Association purports to have as its object only the compilation of a record of practice in the use of storage batteries for operating signals. But it is easy to see that if this record shows any tendency for practice to prefer certain types, arrangements and sizes of batteries and certain operating methods, the moral effect of the inquiry will in the long run be somewhat the same as if the committee had deduced definite recommendations for standards from its investigation. Broadly, therefore, both of the inquiries above noted express the drift toward uniformity of practice, or rather uniform acceptance of best practice.

Such work is, in general, of marked value, as we expressed more at length in our issue of July 12, 1906, and this value is freely recognized. What is much less appreciated, however, is the fact that every standardization or inquiry of this kind involves a great amount of labor, the bulk of which devolves upon the committee entrusted with the inquiry. The men composing such a committee give freely of their time and energy (and frequently of their money), usually without return and often with little or no thanks. The least recognition that their gratuitous efforts merit is the ready assistance of the individual members of the association they represent, in matters such as supplying information about the practice, experience and opinion of the members concerning the subject under investigation.

The engineer in active practice is the target of a goodly number of circulars of inquiry in the course of a year. Not all such inquiries are pertinent and valuable, and there are doubtless many inquirers whose good nature and professional spirit give them undue patience in answering circulars of this kind. The naive impertinence of a certain class of circular requests for information, some emanating from non-technical bodies like aldermanic committees, some even from engineers, has repeatedly been brought before us by complaints from our readers. We would by no means plead for any degree of leniency with such requests, but we desire to emphasize that a request for information which emanates from the committee of a technical society, especially when the committee is appointed for the purposes of standardization, merits by its very source and purpose the most courteous and careful attention. As a broad principle this applies even to such inquiries as that on storage batteries for railway signals, above referred to. This is a document of twenty letter sheets, covering no less than 249 separate questions. It is fair to ask whether the proper scope of a circular inquiry has not been exceeded here. Many of the questions, it is true, may be answered by simple Yes or No; but to make up for this simplification, many others consist of the fascinating little question "Why," in regard to this or that bit of practice or preference. We think it extremely probable that the returns to this circular will bear their own lesson to the over-assiduous authors of the inquiry. In the meantime we suggest that there is a reasonable limit to the extend of the demands which even standardization committees' inquiries may put upon the time and practice of the individuals to whom they address themselves.

The crusade for clean city streets is commendable, and the various means adopted to get children to take a part in the campaign are many of them praiseworthy, but as between dirty streets and such "songs" as the one from which the following lines are taken many people will prefer the dirt. The lines, taken from some verses "sung" at the recent street cleaning convention in Cincinnati, O., are as follows:

No longer will you see a child fall helpless in the street
Because some slippery peeling has betrayed his trusting feet.

* * * * * * * *

And we will keep right on.

But not in singing such songs, let us hope.

TRACK CONSTRUCTION FOR UNDERGROUND RAILWAYS.

Underground railways for city traffic have become so numerous and now form such an extensive and well established system for rapid-transit service that questions of detail may well be considered more carefully than in the earlier days, when the types and methods of construction were the most important problems. One important matter for consideration is that of the track construction. It is desirable to obtain some style of track and floor that not only will make an easy riding and comparatively noiseless line, but will at the same time provide for cleanliness of the tunnel and for the reduction of maintenance to a minimum. All these requirements are important, and especially the last, owing to the difficulty, danger and cost of maintenance work on tunnel lines having a constant traffic night and day. The conditions to be considered in the design of track for underground railways differ in many respects from those affecting railway lines built in the open, but on many lines now in operation these special conditions and requirements have not been given due consideration or study, or else their importance has not been fully realized.

It must be remembered that these underground railways form a class by themselves and cannot be compared with ordinary railway tunnels. The latter form only a small part of the railways, the time of passing through them is short, and the number of trains is comparatively small. Under these conditions the comfort of passengers and the cost of maintenance may not demand a special track construction, although it is probable that in many cases a special type of track would prove economical. In the case of the underground railway, however, the entire work and service of the road and the entire journey of the passenger are underground, so that special attention is demanded to considerations of comfort and of the maintenance of both track and equipment. With circular or "tube" tunnels also, the question of obtaining the greatest possible di-

mensions of the cars within the given limits of clearance must also be taken into account.

One of the main points for consideration is whether the track should or should not be ballasted. In the first place there is a solid and permanent foundation afforded by the floor or invert of the tunnel, and two important conditions affecting track in the open are entirely eliminated, namely: the heaving of roadbed due to frost, and its settlement due to consolidation of embankment material and the effects of wind and rain. This means that ballast will not be required for the purpose of leveling up the track to compensate for the irregularities or disturbance of the roadbed. In the second place, freedom from dust is desirable, both for the comfort of the passengers and for the preservation of the machinery; but if ballast is used, its disintegration with consequent dust is inevitable. Not only this, but the ballast will retain dirt, expectorations, and refuse thrown from the cars, which will in turn add to the dust, and probably cause more or less offensive odors. With a ballasted track, therefore, the tunnel cannot be kept clean and odorless.

Another important consideration is that of noise due to the trains, and it has been very generally assumed that in order to reduce this a ballasted floor is essential. This is far from being the case, however, especially if stone ballast is used. Gravel is a better absorbent of such noise and vibration as are due to the track, but the Metropolitan Ry. of Paris, which uses both stone and gravel, reports that on all new lines *sand* is to be used to deaden the noise.

This is certainly a promising departure, provided sand can be secured sufficiently coarse and sufficiently free from fine particles not to be blown about by the wind produced by the train's motion. If, however, the sand is moved by the draft, more or less will settle on the top of the rail, will there be crushed to powder and then will produce an abundance of dust in the tunnel. Perhaps tarring or oiling the sand might be tried; but if this were done the odor would doubtless be objectionable. In fact the use of creosoted ties on some of the Paris lines has been found to be decidedly objectionable in this respect. As to the noise, also, it must be remembered that a large portion of this is due to the rattling of chains, couplings, trucks, axle boxes, etc, and would not be at all reduced by a ballasted floor. This was shown in discussing the investigation made for the purpose of reducing the noise of the Chicago elevated railways (Engineering News, Dec. 7, 1904). It was then shown that to encase the steel structure in concrete to absorb the vibrations (as had been proposed) would not be likely to have any beneficial effect at all proportionate to its cost and possible disadvantages. It has been shown many times that noise due to the track (including rail joints) may be materially reduced by burying the rail in some material, and this has been tried on part of the Chicago elevated loop, where a plank laid on the ties between the track rail and guard rail supports a filling of tar and gravel composition. It is strange, therefore, that in all cases of track construction on underground railways (with two notable exceptions at London and Philadelphia, noted below) the rails are left exposed.

One other point to be considered is that of making an easy riding track. For this a ballasted floor is sometimes considered to be essential, but it appears evident to us that this is not the case, especially when it is considered that on some lines there is coarse broken stone ballast only a few inches deep under the ties and resting upon a rigid concrete foundation instead of upon a soft roadbed. Furthermore, the relation of ballast to maintenance work must be considered. Where loose ballast is used, its inevitable wear and settlement must be made good by tamping it under the ties so as to keep them supported and in proper surface. But in doing this it is essential that care be taken not to raise the general surface, as a very slight change in the level of the track may reduce the car clearance to a dangerous extent, especially in tube tunnels. It is, however, very difficult to make nice and slight adjustments of track surface by tamping, and as the normal clearance is sometimes only about an inch (or even less) it will be seen that this is an important matter. It is also another strong argument against the use of ballast and in favor of a track construction giving a permanent level to the track surface.

Thus it would appear that ballast is not necessary on underground railways for the purpose of maintaining the surface or absorbing shock and vibration; on the other hand, it is objectionable in producing and collecting dust and preventing the cleaning of the tunnel floor, while it requires tamping and other maintenance work which should be reduced to a minimum on lines of this class, on account of its danger and expense.

In street railway construction it is now very common practice to use stiff heavy rails resting upon concrete, and embedded in paving material or concrete. It would seem that such a construction should be eminently adapted to underground railways, the rails being embedded either in concrete or some other composition, and being perhaps laid upon longitudinal timbers, in order to make the track quiet and easy riding, although the necessity of this last arrangement is open to doubt. The concrete floor above the level of the rail base should be formed with grooves the full width of the rail, these being filled with concrete or composition after the rails are laid. With this arrangement, which is sometimes adopted for tracks in shop floors, the grooves can be cleaned out and rails renewed without breaking up the main part of the floor. Of some sixteen underground railways in this country and abroad, however, only two have followed this type of construction, and in both these cases (at London and Philadelphia) the tracks are to be used by street or surface cars.

In another column we have described and illustrated the types of track adopted for a number of American and foreign underground lines, and it may be of interest here to briefly review the development of track construction on lines of this class.

Underground railways for city traffic were first introduced in London, England, where the first section was opened as long ago as 1863. Their rapid development in that city has been due in large measure to the great size of the city and the amount and congestion of its street traffic; the development has been further aided, however, by the powerful opposition to the introduction of surface railways in the streets, and it is only within quite recent years that surface lines have been allowed to extend from the suburban districts into even the outlying parts of the vast business area. In the early days of the underground lines it is probable that little consideration was given to the question of track construction, which was naturally regarded as of secondary importance as compared with the problems of tunneling beneath a densely built-up city. They were considered principally as ordinary railway tunnels, built under special difficulties, and were first designed as double-track brick-lined tunnels. A considerable part of the early lines, however, was built as "cut-and-cover" in shallow open cuts with vertical walls and a flat roof of transverse beams and brick jack arches. In both cases the ordinary style of track was used, with a thick bed of ballast upon the invert.

The two original lines were the Metropolitan Ry. and the Metropolitan District Ry., which were in a few years extended to form a continuous belt line; since that time numerous underground (city) and open air (suburban) extensions have been built. The Metropolitan Ry. was built mainly as a double-track brick-lined tunnel (the earliest portions wide enough for tracks of the 7-ft. broad-gage); the track construction consisted of timber cross ties laid in a bed of stone or gravel ballast upon the invert. The first rails used were of tee section, but instead of having the stiff form of the original design of the American inventor, Stevens (1830), having a relatively high web, they were based on the modified design introduced by the Engineer Vignoles (1836) which embodied low height and great width of base. The latter is, of course, distinctly inferior as a rail section. The rails were of great size for those days, weighing 86 lbs. per yd., and being 4.20 ins. high and 6.37 ins. wide on the base. In 1874 however, 87-lb. bull-head rails carried in chairs were adopted by the Metropolitan District Ry. following general English practice in track construction, and this construction was also substituted for the existing tee rails.

In 1885, Mr. (now Sir) Benjamin Baker read a paper on the Metropolitan Ry. before the Institution of Civil Engineers, and in the discussion the suggestion was made by Mr. T. R. Crampton that a permanent foundation for the track might be used to reduce the expense and danger of track repairs in such long tunnels. This would form a part of the invert, and upon it would be longitudinal timbers for the rails, a thin sheet of elastic material being laid beneath the timbers. In reply to this, another noted engineer, Mr. (now Sir) John Wolfe Barry, stated that he did not think such a system would be convenient for a line having the numerous curves of the Metropolitan Ry., and it would also be too rigid. The difficulty of track repairs was so great that it was necessary to consider what style of track would be most suitable for making repairs during the few hours (1 to 4 a. m.) that the traffic was stopped. For this purpose, in his opinion, a track with bull-head rails in chairs or wooden ties was more convenient than any other system with which he was acquainted.

This was, of course, before the days of "tube" railways, and it may be noted that both the Metropolitan and Metropolitan District railways have now been converted to electric traction, while the electric trains run more frequently and run all night, so that the track repair work is still more difficult and dangerous than formerly.

In these early lines, little consideration was given to the problem of reducing dimensions to a minimum, and the tunnels were of large size, operated by locomotives and cars similar to those used in general railway service. In fact, as the system developed, the lines came to the surface and connected with main lines, whose suburban trains operated a continuous service over the underground and surface lines.

The opposite extreme was reached, however, when the first of the now numerous "tube" lines was built, in which each track was laid in a separate circular iron-lined tunnel. The first of the "tube" underground railways was the City & South London Ry., opened in 1890. In order to build this line at a low cost, so as to be able to interest capital in such a new enterprise, the two single-track tunnels were made as small as possible, the clear inside diameter being only 10 ft. 2 ins. This made it necessary to keep the track low, and tee rails were used, thus eliminating the extra height due to the cast iron supporting chairs for bull-head rails. The rails were (on the original portion of the line) laid upon timber cross ties resting upon the tunnel lining. Although this railway had many serious defects it sufficed to show the possibilities of lines of this class. In later lines, the tunnel diameter has been increased to about 11 ft. 6 ins.; 12 ft. 2 ins. in one case, and 16 ft. in another case where the ordinary trains were to be operated. Different types of track have been used, ranging from a 3½-in. bridge rail (which proved much too shallow) to the ordinary English rail in cast-iron chairs. In view of the limited clearance (sometimes little more than an inch) and the desirability of having cars as large as possible, it seems strange that this latter arrangement should be used, since it unnecessarily increases the height of the track, but at the same time it may be noted that on some of the latest lines the cars are of special design and have the bodies set very low, the top of the sills being only about 22 ins. above the rails. London has now about 22 miles of "tube" lines in operation, and 18 miles under construction.

The Central London Ry. was the second railway of this class to be opened, and is the most important of the "tube" lines, being a main artery for rapid transit and local traffic. For this line a concrete floor supporting longitudinal supports for the rails was adopted, but a great mistake was made in adopting a very shallow rail of the old "bridge" rail section, invented by Stephenson in this country (1834) and by Brunel in England (1835). This rail as adopted on the Central London Ry. weighed 100 lbs. per yd. and had a width of 7 ins. but was only 3½ ins. in height. The rails were bolted to the longitudinals but the bolts were 5 ft. 6 ins. apart, staggered so that bolts on opposite sides of the rail were 2 ft. 8 ins. apart. This wide spacing of the fastenings, combined with the lack of stiffness in the rail, allowed a wave motion in the rail independent of the longitudinal, and under the action of heavy electric locomotives with insufficient spring support the rails soon became irregularly worn. This resulted in serious vibrations of the surrounding soil which were communicated to buildings and led to such complaint that the Board of Trade appointed an engineering commission to investigate the matter. Very careful and extensive observations and tests were made, both in the tunnels and in buildings about which complaints had been made. The commission's report laid the blame primarily upon the rail, with its irregular surface and lack of rigidity, and it was recommended that stiffer rails should be used on future lines of this class. Owing to the limited clearance in the Central London Ry. tunnels, however, no change was made in the track, but the trouble was avoided by the substitution of motor cars in place of the electric locomotives, thus eliminating the heavy axle loads and heavy shocks due to the latter. In regard to the rail section, it seems strange that such a section, and with such widely spaced fastenings, should have been used in the first place. Experience in Germany has shown that light rails on steel longitudinals and with much more numerous fastenings, develop a wave motion under traffic which causes severe wear of both the rail base and the longitudinal.

In the latest of the London tube railways a type of track construction has been adopted which seems open to criticism in several respects. In all the other modern underground railways of that city, built for electric traction, ballast has been entirely dispensed with, but for these new lines a combination of concrete and ballast has been adopted. The rails are of bull-head section carried in cast-iron chairs, which thus add unnecessarily to the height of the track and in so much diminish the clearance. These chairs are fastened to cross ties only 5 ins. thick but having the unusual width of 14 ins. (10 ins. at joints), and the ties rest upon a bed or bank of concrete of such width as to support them only at the middle portion between the rail chairs. Under the overhanging ends of the ties is packed ¼-in. stone ballast consisting of washed granite. The avowed purpose is to ensure a certain amount of elasticity in the support under the rails, but with ties only 5 ins. thick it seems evident that there will be enough deflection to disturb and crush the stone, causing dust that will be injurious to the bearings and machinery and a discomfort to the passengers. The tamping of this ballast under the ties to make good the loss by such wear will be a very difficult matter, as already noted in regard to ordinary ballasted track, and may result in getting stones between the ties and the concrete bed. It is reported, however, that the track is satisfactory in itself and causes no vibration (the trains being operated by motor cars on the multiple-unit system), but as the line has only been in operation for a few months it is too early for any definite result to be noted.

In this connection it may be of interest to note that 5 ins. is the standard thickness for ties on English railways. In this country 6 ins. is the minimum for main track service, and many railways are using thicker ties, while the American Railway Engineering & Maintenance of Way Association recommends a thickness of 7 ins. At the same time the ties are spaced closer on American railways, thus giving a better support to the rail and a better bearing upon the ballast. It is true that English locomotives and cars are lighter than those of American railways, but even making allowance for this difference it would seem that 5 ins. is barely sufficient for modern track and equipment. This view is substantiated by derailment accidents for which the British government inspectors have been unable to find any apparent cause.

In the construction of a subway for the passage of electric street cars under a certain portion of the city of London, a type of track has been adopted which is simple and substantial and seems likely to reduce maintenance work and cost to a minimum. Timber longitudinals are embedded in the concrete base, and upon these are stiff and heavy girder rails, whose tops are flush with the finished surface of the concrete floor. Thus there is a solid and permanent construction, with cleanliness, and little opportunity for wear, while it is not likely that the noise will be serious.

Coming now to American practice in underground railways, we find that at New York, Boston and Brooklyn the usual track construction has been adopted, with rails laid on wooden ties embedded in ballast. When, after many years of preliminary work, the underground railway or subway system for the city of New York reached the construction stage, plans were prepared for a steel and concrete permanent floor system, without ballast and having the rails carried in troughs so as to hold the wheels in line in case of derailment. It is unfortunate that this system was not adopted, but that an ordinary ballasted track should have been used, which not only requires considerable maintenance but is the cause of both dust and smell. The concrete system was advocated by the engineers, but was not adopted by the contractors (whose contract included both construction and operation), on the ground of its expense and novelty. It is to be noted that in this case the ballast has a depth of only 5 ins. under the ties, which must certainly be considered as the lowest permissible limit, as has been shown by experience. The new subway at Philadelphia, however, is notable in having an unballasted concrete floor; two of the tracks (as described elsewhere) have rails resting upon iron chairs and entirely embedded in concrete; the other two tracks (for express trains) have steel longitudinals embedded in concrete and carrying wooden blocks to which the rails are attached.

In conclusion it may be said that all arguments and experience point to the desirability of a track which is permanent in construction and in level, and which will require little of the maintenance required by ordinary ballasted track in the open. Deep and stiff rails laid upon and embedded in concrete appear to offer many advantages in these respects, and with a concrete floor it will be comparatively easy to keep the tunnel free from dirt and odor as it can be thoroughly cleansed by flushing with water and sweeping the wet surface with brooms. There appears to be no argument in favor of ballast, except cheapness of first cost and ease of laying; its many disadvantages have already been noted. The less wood that is used the better, and with ballast eliminated ordinary ties can easily be dispensed with. Where it is considered advisable to interpose wood between the rail and the concrete, the timber (whether in longitudinals or short blocks) should be embedded in the concrete floor. In order to reduce the noise, the rails should also be embedded in concrete or some composition, the floor being made level with the rail head. In regard to the possibilities and dangers of derailments on underground lines, it is an easy matter to so design the track as to place each rail or each track in a trough or trench, the sides of which will act as permanent guard rails, so that derailed wheels would run upon a smooth surface instead of jolting over ties and ploughing into ballast.

LETTERS TO THE EDITOR.

A Long Railway Curve at Maximum Grade.

Sir: Among the long curves on railroads in the United States, I would like to call attention to one graded under my supervision twenty years ago. This curve is doubtless exceeded in length by many in the United States, though I doubt if the combination of long tangents and curve, at maximum grade, and perfect fit, is surpassed in the country. Crossing the Silver Creek Divide, and dropping down into the Little Prickly Pear Canyon, the Montana Central Ry. follows a tangent 2 or 3 miles long, then a 30-minute curve, as I recollect it something over a mile long, and then a half-mile tangent. At least 2½ miles of this location, including the curve, is at maximum grade. This line was located near the beginning of the year 1886, by Mr. E. H. Beckler, M. Am. Soc. C. E., and the fit of the curve was perfect.

Truly yours, William P. Snow.

Welland, Ontario, July 24, 1906.

A Method Of Preventing Leaks Along Reservoir Outlet Pipes.

Sir: In and near the Kern River oil field, near Bakersfield, Cal., many large earth reservoirs have been built in which the cheap crude oil is stored. Early in the history of that field several reservoirs of 100,000 bbls. or less capacity each were lined with concrete. This was found to be somewhat expensive; besides, the concrete lining was apt to crack, allowing more or less leakage. In some cases also the oil leaked out at the connections of the outlet pipes, where earth came in contact with the smooth iron pipes which were laid through the embankments. The writer suggested that such pipes be surrounded for a few feet of their lengths with a mixture of fine dry earth and heavy crude oil. More than a score of reservoirs have been built with their 10-in. outlet pipes so laid, and at last reports no leaks have developed at the connections although the pipes have no flanges inside the embankment. The mixture of earth and heavy oil is elastic and adhesive, and I firmly believe would prevent the leakage of water under high pressure. I hope that some of your readers will try it and report.

Edwin Squire.

Claremont, Cal., July 16, 1906.

The Lobnitz Rock Breaker and "Fresh Scythes."

Sir: In your issue of May 3, 1906 (page 499) you mention M. Bunau Varilla (to whom you refer as the "volatile French diplomat-engineer") and his advocacy of the use of the Lobnitz Rock Breaker on the Panama Canal work. You remark "The Lobnitz Rock Breaker is nothing new. It was brought before the engineering world many years ago."

In this connection, it might be worth while to mention that, in "Nouvelles Annales de la Construction," for March, 1890, there appeared a description of the Lobnitz system, and of the "Dérocheuse," as Mr. Lobnitz's first machine was called. A translation of this paper was read before the Engineers' Club of Philadelphia on May 3, 1890. While I was serving upon the Publication Committee of the Club, in 1891, this translation was submitted for publication in the Club "Proceedings." At the end of the list of items making up the cost of operation, I was surprised to notice the item, "Fresh scythes, $8.50." I could not help wondering how scythes could be used in connection with the breaking up of rocks under water, and, if scythes were required in such operations, why they need be "fresh." My doubts led me to refer to the original and to the French dictionary. In the former I found that the reading was "faux frais," an idiomatic expression for "incidental expenses," and from the latter it appeared that the translator had found 'scythe" as one of the meanings of "faux," while "frais" was defined as "cool, fresh, etc." It will be easily seen that, by putting this and that together, he arrived at his rendering of "faux frais" as "fresh scythes" in place of "incidental expenses."

John C. Trautwine, Jr.

257 South Fourth St., Philadelphia, July 23, 1906.

The Design of Concrete Steel Beams and Slabs.

Sir: Referring to the papers by Mr. Edward Godfrey, published in your issues of March 15 and July 12, I contend that the formulas and rules given by Mr. Godfrey are not sanctioned by practice.

Tests have shown that the adhesion between steel and concrete decreases with the diameter of the rods embedded (Service Français des Phares et Balises, etc.), and following the rules given by Mr. Godfrey, to use rods of a diameter no more than 1-200 of the span of the beam, the designer will, in many cases, get too small rods. For example, for a beam of a span of 6 ft. the rods are to be $\frac{6 \times 12}{200} = 0.36$-in. = about ⅜-in. A good designer will never use ⅜-in. rods in a beam. Rods for beams especially should have sufficient stiffness not

to bend at many points under the load of the concrete. If too small rods are used it will be very difficult to assure their distance from the bottom. To choose the proper diameter of the rods in each case the designer should have had practical experience; otherwise he may sometimes choose rods not easy to handle and which will not always allow him to get into the work the reinforcement made with a pencil on drawing paper in the office.

As for the space between the rods, the rule given by Mr. Godfrey will induce the designer to use too large beams. In such beams longitudinal cracks occur between the rods.

Stirrups are very useful and increase the strength of the beam. Well designed beams reinforced with stirrups will not fail as shown by Mr. Godfrey on the sketch on page 30 of Engineering News of July 12, though the height be greater than 1-10 of the span, and by the by, I would ask Mr. Godfrey why, in the example given by him (Eng. News, March 15), he does not follow his own theory, assuming for the main girder of a span of 20 ft. a depth of 32 ins. instead of $1\text{-}10 \times 240 = 24$ ins. As for the economy of beams designed according to the rules given by Mr. Godfrey it seems to me to be very problematical. A steel area of 1¼% may be, when the depth and width of the beam are increased beyond certain limits, too expensive for the purpose. To get a good idea about the cost of reinforced beams I would suggest that the weight of the steel be given in pounds and the amount of concrete in cu. ft.

Very truly yours,

Michael Morssen.

38 West 26th St., New York City, July 15, 1906.

Engineering Work in the Western Part of South Dakota.

Sir: Thinking that a description of some of the engineering work now being done in this part of the United States may be of interest, I send you an account of a professional trip I am just completing through the western portion of South Dakota.

As state engineer, my office is at the State Capital, Pierre, a city on the Missouri River, near the geographical center of the state. A journey from Pierre to the Black Hills under present conditions is quite an arduous trip. In order to go from Pierre to Deadwood by rail the route is east to Huron, S. Dak.; thence south to Sioux City, Iowa; thence west to Chadron, Nebr.; thence north to Deadwood. By this route it is necessary to traverse a distance of 881 miles, through three states in order to go a distance of 200 miles by direct route. This condition of affairs, however, will soon be remedied, since two railroad lines are now under construction between the Missouri River and the Black Hills and a third line is projected.

Just before leaving Pierre I visited the scene of operations at the Chicago & Northwestern Railroad bridge across the Missouri River at Pierre. Work is being pushed on completing a temporary pile bridge across the river for use during the construction of the permanent bridge. This latter structure is now under way, work having begun on the east pier. A visit was also made to the end of track which at the time, July 10, was just seven miles west of the river. A Roberts tracklaying machine was being used. At the time of my visit, which was in the afternoon, the machine was idle, the entire force being engaged in spiking and lining up what track was laid in the forenoon. While no opportunity was had to see it in operation, this machine appears from inspection to be efficient and well made.

Little of engineering interest was seen on the trip between Pierre and Rapid City. Rapid City was passed in the forenoon of the second day. Considerable activity in new construction is to be seen adjacent to this place. Tracklaying on the C. & N. W. Ry. line between Pierre and Rapid City is in progress at this terminus, the end of track having advanced several miles east from the latter place.

Deadwood was reached in the afternoon of the 13th. This is a progressive, wide-awake city, with metropolitan airs, and with very little evidence of the strenuous pioneer days left.

The Homestake Co., operating the Homestake mine in Lead City, a few miles up the gulch, is building a large plant in Deadwood for the treatment of "slimes" from their stamp mills. These slimes, now running to waste, although carrying only from 60 to 80 cts. of gold per ton, represent in the aggregate a value of something over $2,000 per day. The site of the plant is McGovern Hill, at the junction of Blacktail and Deadwood gulches. An interesting feature is the concrete work used for retaining walls and for foundations. The following information was obtained from Mr. B. C. Yates, Assistant Chief Engineer for the Homstake Co., who is in charge of the work: About 5,000 cu. yds. of concrete are required, the proportions being 1 : 3 : 5. Atlas and Ideal Portland cement, costing about $3.25 per bbl., is used. Labor costs $2.50 per day. The cost of concrete in place is from $7 to $8 per cu. yd.

From Deadwood I went to Belle Fourche, whence a visit was made to the U. S. Reclamation project now under way. This project was described in Engineering News for Feb. 22, 1906. At the headworks good progress is being made on the diverting dam. This structure is well toward completion, and work will soon be started on the middle section, which, when completed, will close the gap now existing in the structure. Mr. H. E. Green is the engineer in local charge of this work; the contractor is S. R. H. Robinson. In company with Mr. R. F. Walter, Project Engineer, I drove down the line of the inlet canal to the site of the big earth dam now under construction. Mr. W. W. Patch is the engineer in local charge; Orman & Crook are the contractors. The earth, after being deposited on the embankment, is spread and sprinkled and then rolled. For rolling and compacting a 10-ton asphalt roller was first used, but failed to work satisfactorily over the uneven surface of the newly-deposited material. A 20-ton Reeves traction engine was then tried and affords satisfactory results. Sprinkling is effected by means of hose. Work on the completion of the inlet canal, leading from the diverting dam to the Owl Creek Reservoir, is being carried on by the Reclamation Service by day labor. After the failure of the contractors when the work was about three-quarters completed the Government advertised for bids for completing the work, but no bid was received. In consequence the work is being done by day labor as stated. It is expected to complete the inlet canal this season in time to allow arrangements to be made for a partial application of water for irrigation next season.

While in Belle Fourche I saw a lady civil engineer, the first I have known of in my experience. This young lady, Miss Helen M. Thompson, assists her father, Mr. H. E. Thompson, a surveyor in general practice, in his field work, running transit and level, keeping field notes, etc.; also doing drafting work in the office.

After leaving Belle Fourche I went to Hot Springs, and thence out about 14 miles to Cascade Creek to inspect irrigating conditions. Cascade Creek is an interesting natural phenomenon in that it is formed by springs which gush out in full force, flowing at the rate of 20 cu. ft. per sec. This stream irrigates 1,000 acres of land, forming a fertile valley, before flowing into the Cheyenne River.

Yours truly,

Samuel H. Lea.

Belle Fourche, S. Dak., July 18, 1906.

THE COMPRESSED AIR PLANTS USED IN BORING THE EAST RIVER TUNNELS OF THE PENNSYLVANIA RAILROAD.

As is well known, the Pennsylvania Railroad will enter New York City from Jersey City, N. J., through tunnels under the North River (Eng. News, Vol. XLVI., p. 473). The tracks will cross Manhattan through subways and pass under the East River in tunnels to Long Island City, where they will connect with the Long Island R. R., which is now controlled by the Pennsylvania Co. The single track tunnels under the North River consist of two parallel cast-iron and concrete tubes carried on screw piles (Eng. News, Vol. L., p. 326, 331), while those passing under the East River consist of four of these tubes (Eng. News, Vol. L., p. 393), two for through traffic and two for suburban traffic. These two sets of subaqueous tunnels are connected by concrete or brick arch tunnels, which penetrate the solid rock of Manhattan Island, and con... at the new passenger station (Eng. News, ... LI., p. 523, LV., p. 567) being built between ... and 33d Sts. and 7th and 9th Aves., New ... City.

In all this work compressed air plays an important part, especially in boring the river tunnels, which is the greatest undertaking in the history of subaqueous tuneling, while the power plants by which the work is carried ... are the largest ever installed in pneumatic practice. This article will only deal, however, ... the systems of air power production instal... to handle the subaqueous work of the East R... tunnels.

The specifications for these compressed ... plants were, in part, as follows:

The plant to be installed and operated by the contra... shall be the best of its kind for the work to be don...

Where work is done in compressed air, it shall be ... ried on day and night without any interruption or ... termission.

The contractor must provide at each shaft an adequate plant, including boilers, air compressors, hydraulic machinery, dynamos and all other necessary plant, with a reasonable duplication to meet unusual and unexpected emergencies.

The air compressors shall be of sufficient capacity to deliver regularly into each heading at least 300,000 cu. ft. of free air per hour at a pressure of 50 lbs. per sq. in. above the normal air pressure, and a larger amount if found necessary during the progress of the work. The air for the compressors must be drawn from the exterior of the power-house and the intake so located as to give pure air. The air shall be cooled, and oil and other impurities removed, as completely as practicable, before delivering it into the headings.

In order to provide a reasonable margin for repairs and contingencies, a spare compressor and boiler plant shall be provided at each shaft and kept in good condition and repair, ready for immediate use. At the Manhattan shafts, the capacity of the spare plant shall be 25% of that required in the preceding paragraph for regular operation, and at the Long Island shafts 12½%.

Provision must be made for storing in tanks at each boiler-house enough feed water for 12 hours' supply, unless connections can be made with two independent and sufficient sources of supply.

The air shall be delivered into each heading through two supply pipes of such capacity that the velocity of the air through them in regular working shall not exceed 40 ft. per sec. These pipes shall be tapped with regulating valves in each intermediate air chamber in tunnels and sufficient air admitted to ventilate it and to maintain the pressure required. If required by the engineer, air shall be delivered at the shield in each section or compartment thereof where men are employed, and withdrawn therefrom in special exhaust pipes with suitable regulating valves.

The most noteworthy feature of these specifications is the enormous volume of free air required for each heading. Since there are eight headings, this gives a grand total of 2,400,000 cu. ft. of free air per hour to be supplied by the air plants, which is equivalent to an effective net piston displacement in the compressors of 40,000 cu. ft. of free air per minute. This air is used to keep out the water by counterbalancing its hydraulic head and also for ventilating the heading (Eng. News, Vol. LVI., p. 43). In addition to this low pressure supply it was necessary to supply a source of high pressure air for operating rock drills, etc.

Space will not permit an extended description of each of the pneumatic power plants nor is it necessary since the Manhattan plant of the East

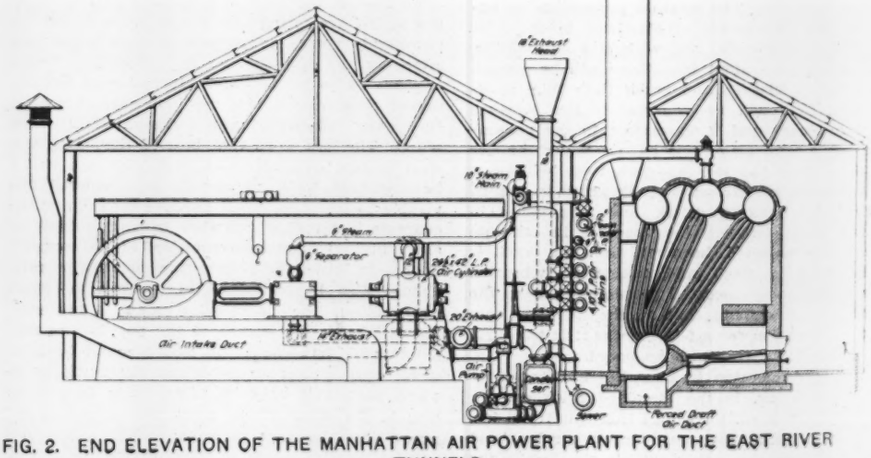

FIG. 2. END ELEVATION OF THE MANHATTAN AIR POWER PLANT FOR THE EAST RIVER TUNNELS.

River tunnels located at 32d St. and First Ave., New York City, is probably the most complete development of the methods designed to meet the operating requirements of the specifications. It will therefore serve as a type, not only of the air power plants used on these tunnels, but also as an example of the most approved practice in pneumatic power production and distribution.

THE MANHATTAN PLANT.

In designing the plant it was necessary for the engineers not only to design a plant that would meet the requirements of the specifications, but also to design it to occupy a given space, thus necessitating a departure from approved power plant design. The general arrangement of the plant is shown in Fig. 1, while an end elevation is given in Fig. 2.

The original equipment of this plant included five water tube boilers each of 500 boiler HP. capacity. Each boiler is provided with an approved setting and is equipped with shaking grates and draft appliances designed for burning the smaller sizes of anthracite coal. They are also fitted with "non-return emergency stop valves" designed to automatically close should there be a backward rush of steam, such as would occur in the event of a broken boiler tube, thus preventing, in cases of this kind, the discharge of steam from the other boilers. Steam is generated at 150 lbs. pressure, the boilers being guaranteed to stand a 50% overload for a limited period. Two independent steam-driven fans, each with a capacity of 28,000 cu. ft. of air per minute delivered at 1½ oz. pressure, furnish a forced draft. These fans are supplemented by individual steel stacks for each boiler, the stacks being 54 ins. in diameter and 100 ft. high. Only one fan is required, however, to furnish the desired draft, which thus leaves the second as a reserve. The air for the forced draft is carried through a large duct in the bridge wall and discharged into the ash pit of the boilers, the discharge being controlled by two draft dampers arranged to give the best possible distribution of air under the grates. The water level in each boiler is automatically maintained at a fixed point by means of a feed-water controller, consisting of a float in the water column, which actuates a valve in the feed-water connection to the boilers, which in turn regulates the speed of the pump through a pump governor.

BOILER FEED PUMPS.—The boiler feed water is supplied by a duplex feed pump of the outside-packed plunger pattern, brass fitted throughout and provided with a governor. Two similar pumps are held in reserve for emergencies. These pumps draw their supply from a 2,000-HP. open feed-water heater, which receives the exhaust steam from the boiler feed pumps, the circulating pumps, the air pumps, the fan engines and the other auxiliary machinery. A secondary heater receives the overflow of the main heater, thus eliminating all loss of steam and water from the system except a small amount due to leakage. The main hot well, a heavy steel tank, receives all the water of condensation from the condensers. This water is lifted to the main heater by duplex brass-fitted pumps controlled by a float in the hot well.

CONDENSERS.—Three 1,800-HP. surface condensers are installed in a pit below the engine room floor, close to the fire wall between the engine and boiler rooms. Each condenser is provided with an individual air pump, driven by a vertical engine, which maintain, in practice, a vacuum of 26 ins. for the whole system. One of these units is always held in reserve. Condensing water is drawn from the East River, through an 18-in. main several hundred feet in length, by means of two centrifugal circulating pumps, each having a capacity of 3,000 gals. per min., and each driven by an independent vertical engine. Either of these pumps can supply two condensers running at rated load, providing the temperature of the condensing water does not exceed 70° F. A steam-driven centrifugal pump with a capacity of 1,000 gals. per min. draws water from the East River through a 10-in. pipe and circulates it through the jackets and coolers of the air compressors. This unit is not in duplicate, but the piping is so arranged that, in case of necessity, its load can be taken by one of the main condenser circulating pumps.

STEAM PIPING.—The steam piping is laid out on a loop system, the boilers being connected to the steam header by wide sweep bends. The main header has a maximum diameter of 12 ins., which diminishes to 10 and 8 ins. in the far sections. The valves are so arranged that any compressor, auxiliary or section of pipe can be cut out without interfering with the operation of the other machines. The main exhaust steam header has a maximum diameter of 20 ins., the remoter sections being 18 and 10 ins. It is provided with two automatic atmospheric connections for exhausting to air in case it is necessary to simultaneously shut down all of the condensers. Valves are also provided for cutting out any or all of the condensers. Standard pipe is used throughout the system, the fittings and valves being extra heavy. The valves are of the gate pattern, and bronze-seated, while all steam pipes are covered with non-conducting material bound with heavy canvas.

As above noted, the feed-water system is automatic in operation. In addition, the piping is so arranged that the boiler feed pumps can be supplied directly from the city mains, and there are also connections which provide for the filling of empty boilers from the city mains without the use of pumps. Two independent pipe lines are also provided between the pumps and the boilers. In passing from the heater the water flows through an oil separator, thence to the feed pumps.

The equipment of the plant also includes three steam-driven hydraulic machines for furnishing pressure to the hydraulic jacks, which are used in forcing the shields forward in the tunnels, and four vertical direct-connected electric generating sets which furnish current for lighting the workings.

AIR COMPRESSORS.—The conditions under which the compressor plants are designed to operate are somewhat peculiar. As already stated, the air pressure is used to balance the outside water pressure. It is thus evident that as the tunnels descend under the river the hydraulic pressure will increase until the tunnels have reached their maximum depth. The varying outside pressure necessitates a corresponding change of air pressure in the headings, and since the different tubes might not progress at the same rate of speed in boring, the plant had to be

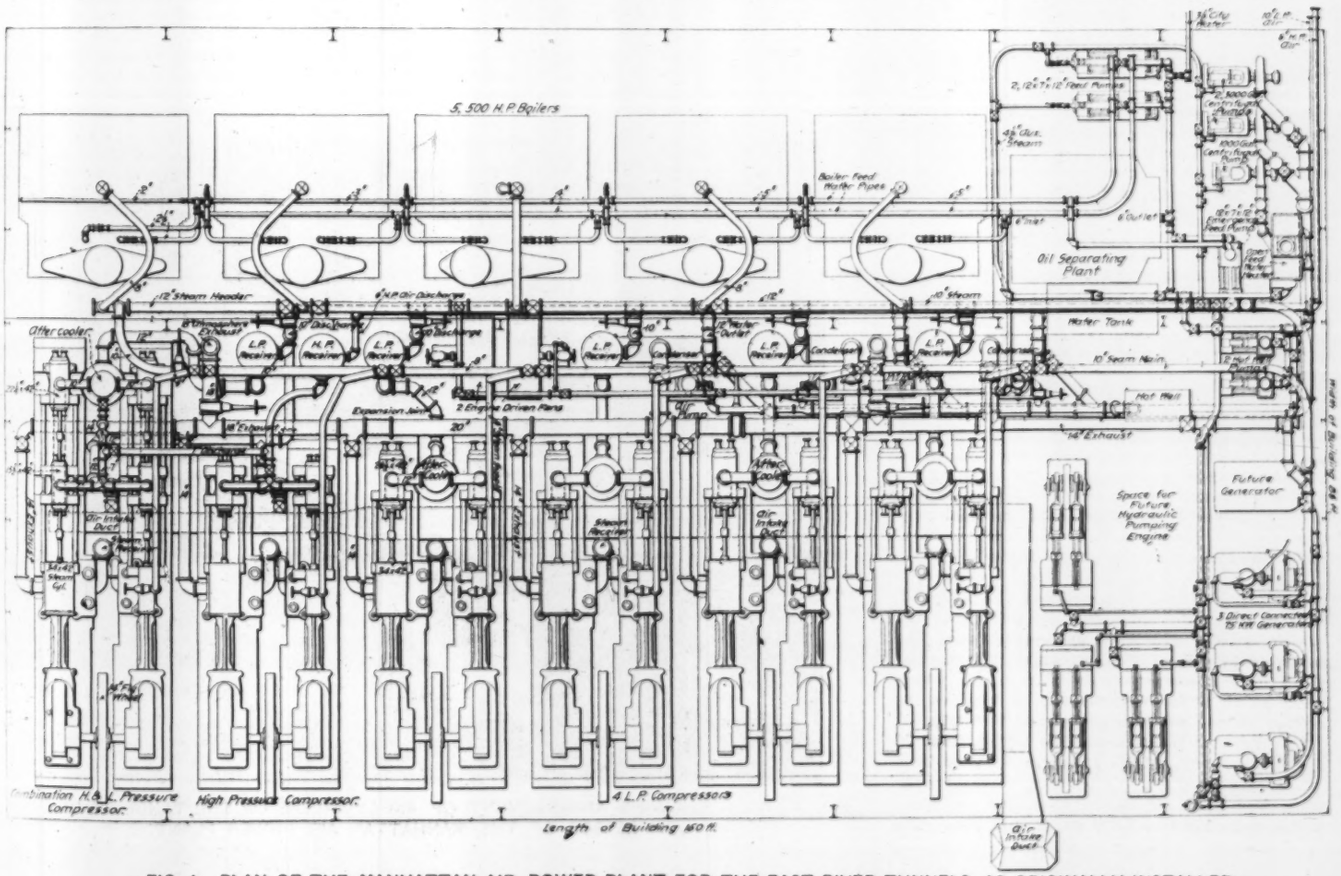

FIG. 1. PLAN OF THE MANHATTAN AIR POWER PLANT FOR THE EAST RIVER TUNNELS, AS ORIGINALLY INSTALLED.

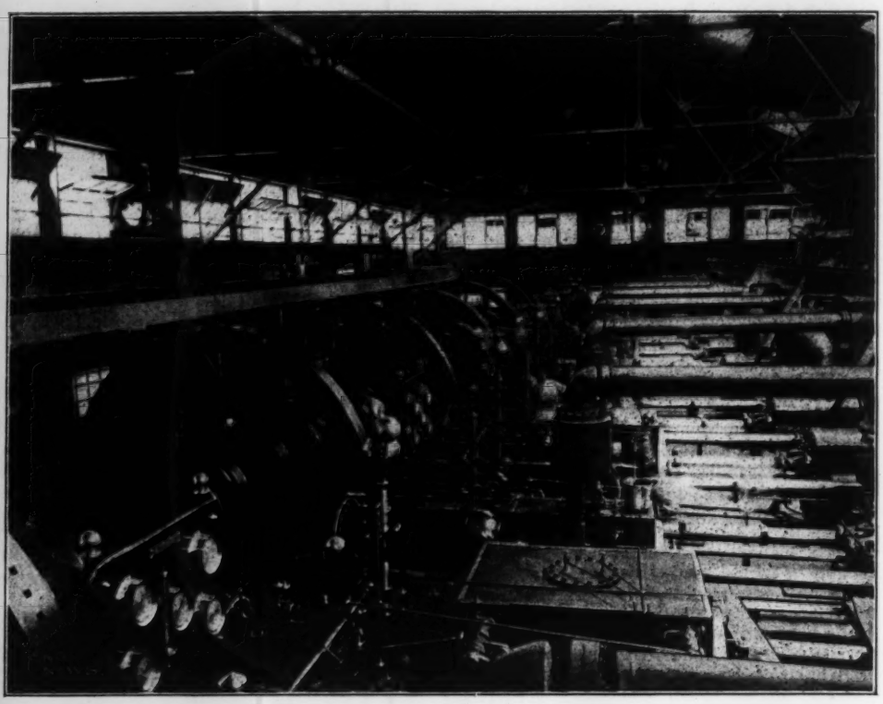

FIG. 3. GENERAL VIEW OF FIVE AIR COMPRESSORS OF THE MANHATTAN AIR POWER PLANT.

laid out to furnish varying pressures in the different headings at the same time. Since the pneumatic drills, etc., exhaust into the pressure on the headings, and as they require a constant effective work pressure, irrespective of the back pressure of exhaust, this necessitated a system of high pressure air so arranged that the air pressure could be varied in the different headings. Summing these conditions up, it is seen that two sources of air pressure, with pressures always differing by a constant, and capable of being raised simultaneously between their maximum and minimum values, were required.

The air power equipment comprises six compressor units. Four of these units are low pressure machines of the duplex Corliss type, with cross-compound steam cylinders designed to operate condensing, and simple duplex air cylinders which discharge into individual after coolers. The steam cylinders are fitted with Corliss release type valve gear, with vacuum dash pots, while the valve gear for the air cylinders is that known to the trade as the "positive pneumatically operated type." These units operate at 150 lbs. (gage) steam pressure and 26 ins. vacuum, with normal rated speed of 100 r. p. m. The steam cylinders are 16 × 42 ins. and 34 × 42 ins., high and low pressure respectively, while the duplex air cylinders are each 26¼ × 42 ins. Running at this speed each machine has an actual free air capacity of 5,000 cu. ft. per min., the working pressure ranging from atmosphere to 50 lbs. The maximum efficiency is obtained, however, when an air pressure of 30 lbs. is being delivered, and, under the above conditions, each compressor then develops about 480 I. HP. Each unit is provided with a specially designed speed and air pressure regulator which automatically controls the steam supply and air pressure, maintaining them at the proper values.

A high-pressure unit of the same general type as the low pressure machines was also installed. This unit has the same style of fittings as the low-pressure compressors and operates at the same steam pressure and vacuum. The normal speed of this compressor is 90 r. p. m., which gives an air piston displacement of 1,568 cu. ft. of free air per min. from atmospheric intake.

The working pressure can be varied from 90 to 140 lbs., with intake pressures varying from atmosphere to 50 lbs. Under these conditions the equivalent free air capacity of the machines varies from 1,568 to 6,899 cu. ft. per min. The high-pressure cylinder is 16 × 42 ins.; the low-pressure 34 × 42 ins., and the air cylinders each 15½ × 42 ins. The maximum efficiency of this machine is obtained when operating at 150 lbs. (gage) steam pressure, 26 ins. vacuum, and a terminal air pressure of 120 lbs., compressed from an intake pressure of 30 lbs. The air cylinders discharge into a high-pressure receiver located in the rear of the compressor. A general view of five of these condensers, installed in the plant, is shown in Fig. 3.

A compressor classed in the specifications as a "combination high and low-pressure compressor" was installed to serve as a reserve for either the high or low-pressure sections of the plant. The machine is of the same type and provided with the same fittings as the other compressors; but the air cylinders are arranged in tandem, Fig. 4, both a high and low-pressure cylinder being operated by the high and low-pressure steam cylinders, a high-pressure air cylinder being located next to and in line with each steam cylinder. This design permits the running of the machine, with all four air cylinders connected, as a low-pressure machine or as a high-pressure machine with the large cylinders disconnected. The low pressure air cylinders are 22¼ ins. in diameter, while the high-pressure cylinders are 15½ ins. in diameter, with a common stroke of 42 ins. When operating as a low-pressure machine, at the rated normal speed of 100 r. p. m., this compressor has an actual total capacity of 5,000 cu. ft. of free air per min. from atmospheric intake, and covers a range of terminal pressures varying from atmosphere to 50 lbs. When running as a high-pressure unit, at the normal rated speed of 90 r. p. m. the machine has a free air capacity of 1,568 cu. ft. per min. from atmospheric intake and a discharge pressure of 90 lbs. If the intake is at 50 lbs. the terminal pressure is 140 lbs. and the free air capacity of the machine is 6,899 cu. ft. per min. The maximum efficiency of the unit is obtained when run at 150 lbs (gage) steam pressure with 26 vacuum, the air intake being at 30 lbs. and the discharge pressure at 120 lbs. Under these conditions it develops 430 I. HP. When run as a low-pressure unit it discharges into a vertical receiver-after-cooler, mounted between the low-pressure cylinders, but when operated as a high-pressure machine the discharge is delivered to the high-pressure receiver already noted as connected with the high-pressure unit. No provision was made for after-cooling the high-pressure air, since the moisture is sufficiently removed in the after-coolers of the low-pressure machines from which the high-pressure units usually draw their supply. The exhaust from the high-pressure tools used in the headings is cooled by its expansion. This compressor, as well as all the others here described, was designed for a 24-hour overload up to 125 r. p. m. All air cylinders are water-jacketed and cooled by a continuous flow of river water delivered by the circulating pump.

AIR INTAKE.—In order that the air delivered to the headings might be as pure as possible, each compressor is supplied with air through an 18-in. branch leading from a large intake conduit traversing all the foundations and terminating in a 40-in. vertical, hooded and screened

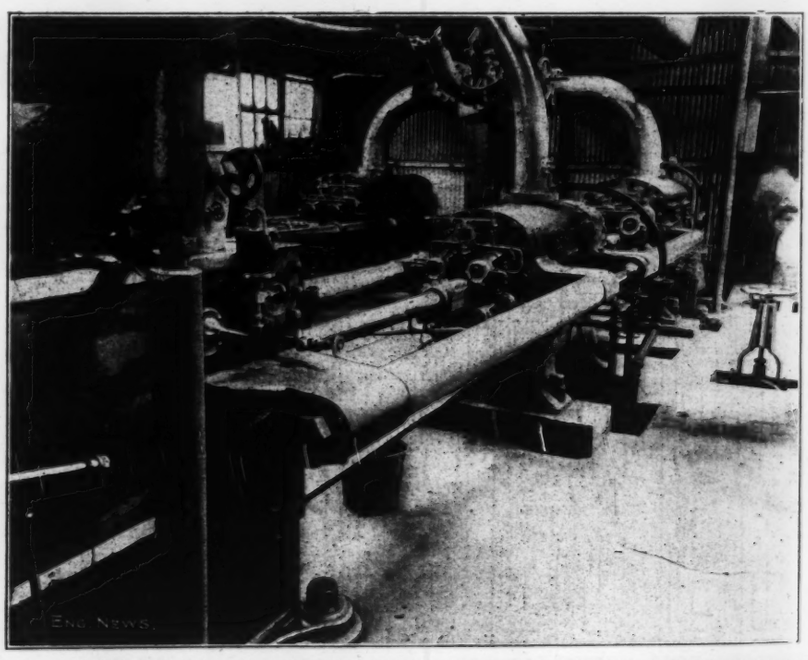

FIG. 4. VIEW SHOWING ARRANGEMENT OF AIR CYLINDERS OF THE TANDEM CORLISS AIR COMPRESSOR OF THE MANHATTAN AIR POWER PLANT.

pipe outside the building. Salt water is used in cooling the after-coolers, which are fitted with tubes and tube plates of special composition to resist corrosion. Each after-cooler reduces the temperature of the air received from the low-pressure cylinder to nearly that of the cooling water employed. The temperature of the air thus cooled is, for most of the year, below that of the external atmosphere.

There are five vertical, low-pressure, steel air receivers, 54 ins. in diameter and 12 ft. high, mounted at the rear of the compressors. The cooled air from the after-coolers enters these receivers at the top and is discharged near the bottom. In passing through these receivers all excess moisture is deposited, as well as most particles of oil. A vertical high-pressure receiver 60 ins. in diameter and 14 ft. high is located at the rear of the high pressure unit.

As already noted, the high-pressure units usually draw their air supply from the after-coolers of the low-pressure machines, which is equivalent in effect and economy to a two-stage compression, while giving a range of capacity under fluctuating pressures and a flexibility under varying service conditions which could not have been secured by any ordinary multi-stage unit. Thus, when the shields were being operated without air pressure the pneumatic drills were operated under an initial pressure of 90 lbs. supplied from the high-pressure compressor. As the bore progressed, and an air pressure was required in the heading, it was supplied by the low-pressure machines, which also supplied the high-pressure compressor. This arrangement keeps the actual working pressure on the drills at 90 lbs. For instance, if the pressure on the heading is 10 lbs. the initial pressure of the high-pressure machine becomes 100 lbs. and so on.

COMPRESSED AIR PIPING.—A 12-in. pipe connects the after-cooler of each low-pressure compressor to a low-pressure receiver. Each receiver is connected by means of a 10-in. pipe and a four-way fitting to four 10-in. air mains running the length of the engine room, one leading to each tunnel. This system of piping is so arranged that any individual low-pressure compressor may furnish air to any tunnel at any required pressure. Also either high-pressure machine may draw its air supply from any low-pressure cooler and deliver it, with correct differential, to any heading. The high-pressure main is a 6-in. pipe carried from the receiver and branched to each tunnel. The intake pipes for the high pressure and combination compressors are so arranged that the machines may draw their air supply from the atmosphere instead of from the after-coolers of the low-pressure machines if it becomes necessary. Piping is also arranged so that the high-pressure machine can supply the low-pressure system.

OILING SYSTEMS.—Three separate oiling systems are used. The first supplies engine oil to all journals and oil cups, the oil flowing by gravity from an elevated tank. After passing through the bearings it is caught and filtered, after which it is returned to the supply tank by a small oil pump. The second system is a forced lubrication system for the air cylinders. Air-oil, contained in tanks under high and low pressure furnished by high and low-pressure receivers respectively, flows into the high and low-pressure air cylinders. A large percentage of this oil is recovered in the drains of the after-coolers and is used for lubricating the rock drills and other air appliances used in the headings. The third system lubricates the steam cylinders and is simply a gravity arrangement of piping by which the cylinder oil flows from a tank to the reservoirs of the individual oil pumps fitted to each cylinder. This oil is removed from the condenser discharge by an elaborate automatic chemical oil separating plant.

LONG ISLAND CITY PLANT.

The pneumatic power plant at the Long Island terminus of these tunnels is located at the foot of Flushing St., Long Island City. This plant is identical in capacity to the one just described, although the arrangement of apparatus is radically different, due to the fact that it had to be located in a given space.

ADDITIONAL APPARATUS.

In the foregoing description only details of the plant as originally installed are given. The list of apparatus should also include two straight line air compressors, 18 and 18¼ × 24 ins., which were used for some preliminary shaft and tunnel work and were retained with the idea that they might be serviceable in an emergency. After putting these plants in operation is was found necessary to enlarge both, as the amount of low pressure air required greatly exceeded all calculations. Accordingly an additional low-pressure compressor, an exact duplicate of the low-pressure compressors already described, and an additional boiler have been installed in each power plant. Moreover, at the Manhattan plant the 15½-in. cylinders of the high-pressure compressor have been taken off and cylinders 26¼ ins. in diameter for low-pressure service substituted.

In designing these air power plants, as well as those used in driving the North River tunnels, the greatest consideration was given to details in order to obtain a maximum economy and reliability in operation. As a result of this care, the plants have given the best of satisfaction in operation; notwithstanding that their combined capacity is far in excess of anything heretofore known for similar purposes, and that their design embodies many features unique in pneumatic practice.

The pneumatic apparatus for these plants were furnished by the Ingersoll-Rand Co., 11 Broadway, New York City, to whom we are indebted for the foregoing information.

NOTES FROM THE ENGINEERING SCHOOLS.

THE UNIVERSITY OF TENNESSEE.—A large addition to the engineering building of the University is now under construction, and will be ready for use at the beginning of the fall session. The building is of red pressed brick, three stories high. The entire first floor will be devoted to shops and laboratories, the second and third floors to class rooms, library, offices, drawing rooms, designing rooms, etc. Electrical, civil and mechanical engineering will be housed in this building.

STEVENS INSTITUTE OF TECHNOLOGY.—The Morton memorial laboratory of chemistry, which was completed the first of the present year, is undoubtedly one of the finest of its type in the country. It is 52 × 118 ft. long and stands three stories high, is without basement and cost about $150,000. Ample provisions have been made for all classes of work, but the thing of special interest is the system of ventilation. Each desk is provided with individual hood and down draft, designed by Prof. D. S. Jacobus, for carrying off the fumes generated in chemical work. These hoods are connected through tile pipes to an exhauster capable of exhausting about 175 cu. ft. of air per min. from each hood. The fumes are discharged into the outer air through the chimneys. It has been found that this system is very efficient, leaving the air of the room untainted and that it works equally well with the windows and doors opened or closed.

A BUILDING COLLAPSED DURING CONSTRUCTION at South Framingham, Mass., on Monday, July 23. The building was to be three stories high, and measured about 150 ft. front by 75 ft. deep; it was planned to be a fireproof structure. The walls were of concrete or concrete blocks, and the floors of concrete on steel girders. The framework, that is walls and floors, was complete at the time of the accident, and the roof was being put in. There are some reports of settlement of portions of the building during the day preceding the accident. Twelve persons were killed in the collapse.

TEMPORARY WORKS FOR THE GREAT SHOSHONE dam in Wyoming, according to Mr. H. N. Savage, Supervising Engineer of the U. S. Reclamation Service, had been completed, so far as possible, early in June, 1906, and were then handling the annual flood. A tunnel 500 ft. long had been driven through the rock ledge along the dam site, and a temporary dam has been completed across the stream 1,000 ft. above the tunnel. A flume conducts water from this temporary dam to the tunnel. The contractors are also damming the permanent spillway tunnel, which is located 240 ft. above the bed of the stream, has a cross-section of 20 ft. square and will have a discharge capacity of 20,000 cu. ft. per sec., ample provision being thus made for handling the greatest flood the river can produce. The water impounded behind the Shoshone dam will be first conducted 16 miles down the main channel of the river and then diverted by means of a tunnel 3½ miles long out upon the land to be irrigated. This tunnel is 10 ft. square in cross-sections and will have a capacity of 2,000 acre-feet of water every 24 hours. Construction work is being rapidly pushed. About 400 men were at work in the early part of June, the nature of the material encountered being exceptionally favorable for rapid excavation. The soft sandstone can easily be drilled by the use of coal boring augers. These are driven by compressed air. Frequently a hole 6 ft. in depth is driven in six minutes.

A LANDSLIDE WRECKED A TRAIN on the New York Central & Hudson River R. R. at Chelsea, near Poughkeepsie, N. Y., on the night of July 29. The tracks run along the east bank of the Hudson River at this point, and were bordered by a steep up-slope on the land side. This sloping bank slid down upon the tracks, and an express passenger train ran into the obstruction soon after. A very heavy rain storm which began about noon continued through the afternoon and evening of July 29, and it is thought that this rain caused the sliding of the bank above the track. The accident caused three deaths.

THE ELEVATED RAILWAYS OF CHICAGO are having two important extensions built. The South Side Elevated Ry. is building an extension southwest to Englewood, and is also completing the three and four-tracking of its present structure, besides entirely rebuilding portions of this structure to improve the alinement at sharp curves. The Northwestern Elevated Ry. is building a branch line in the form of a Z near Graceland; the line runs west from Clark St. along Roscoe St. and across the Chicago & Northwestern Ry., then north parallel with that road and finally west on Leland Ave. to Kimball Ave.

A SUIT FOR INFRINGEMENT OF PATENT ON concrete mixer, involving Patent No. 814,803, of March 13, 1906, has been brought by the Ransome Concrete Machinery Co. against the United Concrete Machinery Co.

THE BOX TUNNEL on the Great Western Ry., near Bath, England, was closed for some days early in July owing to a fall of rock from the roof. The tunnel was built in 1838 under the direction of Mr. I. K. Brunel, and was for a double-track line of 7-ft. gage. It is 1¾ miles long, 36 ft. 6 ins. high, and 36 ft. wide. It is driven through sandstone and is only lined near the ends, where a complete brick lining with crown, sidewalls and invert is used, the thickness at the crown being 27 ins. Traffic was diverted over the other lines of the Great Western Ry. until the tracks could be cleared and the tunnel made safe.

THE CABLE RAILWAYS OF CHICAGO will soon be entirely superseded by electric traction, the city having passed ordinances permitting the Chicago City Ry. and the Union Traction Ry. to install poles and trolley wires on the parts of the cable lines not already so equipped. Cable and electric cars have been running on the same tracks for some time, but until the city authorized the use of wires in certain streets the cable system could not be abandoned. The three cable railway tunnels are to have new roofs built at a lower level to give greater depth of water in the river, and two of these (at LaSalle and Washington Sts.) will be temporarily abandoned, electric cars on the old cable lines being diverted to the bridges. The Van Buren St. tunnel will be kept in operation, both roof and floor being lowered, but there will be no conduits in the reconstructed tunnel, as it will be operated by the ordinary trolley cars. As the companies have for some years had this change in mind, most of the rolling stock of the cable lines is old and more or less dilapidated. A total of about 67 miles of single track will be converted to electric traction, almost equally divided between the two companies. At present the cars will be operated on the existing tracks, but as these are to a large extent old and in bad condition there will eventually be a considerable amount of reconstruction necessary to put the lines in shape to carry the heavy modern electric cars. As fast as the erection of the trolley wires proceeds the electric cars are run over the old cable lines.

PROGRESS ON THE GUNNISON TUNNEL, forming a part of the Uncompahgre project (Colorado) of the U. S. Reclamation Service, is reported as being very favorable. Headings 3 and 4, including the most disagreeable part of the work, have been joined. These headings were under the valley of Cedar Creek, where for nearly a mile the tunnel was driven through river sands and gravels, clay

and soft shales. Work will now be concentrated on headings Nos. 1 and 2, which are under the main part of the mountain. At No. 1, which is in a hard reddish quartz or coarse granite, changing to mica schist, progress has been upwards of 12 ft. a day; while at No. 2, which is in a relatively soft black shale, progress has been 20 ft. a day. At one of the headings the tunnel is now passing through a deposit of sea shells, some of which are said to be 3 and 4 ft. in diameter. These shells sometimes give way without warning, bringing down great masses of black shale from the roof of the tunnel, unless the latter is supported with the greatest care. The work of the Gunnison tunnel is being done by the Reclamation Service direct. On Nov. 17, 1905, the first mile, or one-fifth of the tunnel was completed; on July 1, 1906, the total heading driven was 13,767 ft., of which 1,321 ft. had been done during the month of June. Work is being carried on night and day.

THE REMOVAL OF THE STONE excavated from the Chicago Drainage Canal has been a problem for some years, especially since the Drainage Board has proposed to make part of the bank available for dock or wharf purposes. Along the rock sections extend continuously the high piles of debris, and although some contracts have been made with dealers in broken stone (who have installed crushing and screening plants) the quantities handled have been too small to have any appreciable effect. The Board has now awarded a contract to John M. Ewen, of Chicago, an engineering contractor, which requires him to remove at least 300,000 cu. yds. per year, for which he will pay 10 cts. per cu. yd. and also a percentage of his profits.

LEAD-WOOL FOR CALKING GAS MAINS IN GERmany has been supplied since May, 1904, by Aug. Buhne & Co., of Freiburg, according to the "Iron and Coal Trades Review" (London) for July 13, 1906. The same authority states that the Lead-Wool Co. has established works at Snodland, in Kent, England, for the same purpose. The lead-wool is substituted for molten lead in the ordinary hub and spigot iron joint. The lead-wool is shredded to about the size of heavy thread, collected into bundles of convenient length and of a size in proportion to the joint to be filled, twisted somewhat, and calked cold into the joint against a backing of hemp or tarred yarn, as usual. . . . . It is claimed that lead contracts on cooling from its molten condition when poured into the joint, and leaves a space between itself and the pipe; also that calking only spreads the outer portion of this lead, leaving the inner part free to leak. It is also claimed that the yarn in the joint is not compressed sufficiently in the melted lead joint, but that in the lead-wool joint the strands of lead are packed as they are put in, thus keeping the yarn under compression and filling the joint perfectly full of lead for its entire depth. To accomplish this end a strand of lead-wool is inserted in precisely the same way that the yarn had been put in and calked with the three calking tools in order. These tools do not have square ends, but are dull pointed, having V-shaped ends which tend to spread the lead against the pipe. Then another layer is inserted, calked, and so on, until the joint is filled. The calking solidifies the lead and yet leaves it free to adjust itself, so that when the joint is deflected the lead and yarn adjust themselves and still fill the space. In calking, the lead should be forced from the spigot toward the hub by the tool rather than spreading equally.

With lead-wool there is more yarn and less lead used than with a poured joint. About 75% as much lead is used per joint, but skillful calkers will require less. About half the depth of lead is necessary, but careful calking is essential.

According to some tests made at the Mannesman Tube Works the joints withstood enormous internal hydrostatic pressure, the 3-in. pipe joint just beginning to give way at 3,450 lbs. per sq. in.

MUNICIPAL OWNERSHIP of electric light plants has grown rapidly in public favor of recent years, according to statistics prepared by Edward Bradford Smith, research scholar in political science in the University of Wisconsin. In the past 25 years the number of municipal electric light plants in the United States has increased from 1 to 1,050; the number of private plants has increased in the same time from 7 to 3,234. During this period 13 plants changed from municipal to private ownership, and 170 from private to municipal. Canada has 80 municipal electric light plants. In England over two-thirds of all the electric light plants are owned by municipalities; the figures for the entire United Kingdom are 297 private plants and 481 municipal.

In Wisconsin the first electric light plant was established at Bayfield in 1889, at a time when there were 30 private plants in operation. In March, 1906, there were 46 municipal and 123 private plants in the state, showing an increase in municipal ownership in 17 years from 3⅓% to over 38%. In eleven Wisconsin cities the electric light plant is operated in connection with the municipal water-works.

CEDAR TIES are in high favor on the Grand Trunk Ry., of Canada. At the Canadian Forestry Convention a statement on this subject was made by Mr. Joseph Hobson, Chief Engineer of the road named, to whom we are indebted for a corrected copy of the statement. Mr. Hobson held that so far as comparative immunity from decay was concerned, cedar was the best Canadian timber of which he had any knowledge. The greatest objection to cedar ties was that they were likely to be broken in the event of a derailment. On the principle of choosing the lesser of two evils, he considers that a practically imperishable wood, so far as decay was concerned, was better than a material that developed more or less weakness, and possibly might lead to accidents after but a very few years' service. The present annual tie consumption was only about half of what it was before the cedar ties were brought into use, and in no instance, to Mr. Hobson's knowledge, was any derailment directly attributed to them. Of about 2,200,000 cedar ties bought by the Grand Trunk Ry. in 1905, about 150,000 were obtained outside of Canada. On the Grand Trunk Ry. system during the seven years between 1896 and 1904, the average annual number of ties used was 2,102,653, or say 63,000,000 ft. B. M. In 1904 the total quantity of timber used for all other purposes was 30,846,000 ft. B. M., so that the total consumption of timber on the Grand Trunk Ry. system might therefore be called 95,000,000 ft.

AN ELEVATED ROADWAY for Market St., San Francisco, has been projected. A plan has been submitted to the city for reconstructing Market St., by which the present level would be reserved for railway tracks and heavy trucking, while an elevated roadway to accommodate foot passengers and the lighter vehicle traffic would be built of concrete and steel. The proposition has been made by the engineering and contracting firm of Reed & Co., which estimates the cost of construction at $5,500,000, and offers to do the work at cost-plus-a-fixed-percentage (10% of the estimated cost), and to accept in payment 5%, 30-year city bonds. The length of the roadway would be about three-fourths of a mile, extending from Kearny St. to the Ferry building, and about two years' time would be required for its completion. The plan involves using the present sidewalk space for steam railroad tracks; the electric car tracks would remain where they are; the space intervening would be for heavy trucks. Cross subways would be provided at the junctions of intersecting streets. The upper or boulevard level, it is said, would be of architectural beauty; the plan includes a "court of honor" at the Ferry building terminus, and a wide park extending along the middle of the roadway. It is urged as a point in favor of the project that the steel structure tied to the buildings on each side of the street would materially strengthen them and thus render this section of the city "practically impregnable to earthquake and similar disasters."

THE SEWER PIPE TRADE ASSOCIATION, popularly believed to control the sewer pipe trade in the northeastern part of the United States, recently appeared before a Federal Grand Jury at Jamestown, N. Y., and offered to dissolve voluntarily rather than have a suit brought against it under the Sherman anti-trust law. It is said that according to evidence collected by District Attorney Charles H. Brown the association included the following companies: American Sewer Pipe Co., Pittsburg; Buckeye Sewer Pipe Co., Akron, Ohio; Clearmont Sewer Pipe Co., Clearmont, Pa.; Duquesne Fireproofing Co., Pittsburg; East Ohio Sewer Pipe Co., Irondale, Ohio; Federal Clay Manufacturing Co., New York City; James Loeb Co., Urichsville, Ohio; New York State Sewer Pipe Co., Rochester; Patton Clay Manufacturing Co., Patton, Pa.; Pittsburg-Buffalo Co., Whiterock, Pa.; Portland Stoneware Co., Portland, Me.; Robinson Clay Product Co., Akron, Ohio; Robinson Graves Co., Urichsville, Ohio; Shawmut Clay Manufacturing Co., Urichsville, Ohio; St. Mary's Sewer Pipe Co., St. Mary's, Pa.; Kane-Aberkersch Co., Toronto, Ohio; Stratton Fire Clay Co., Empire, Ohio.

CEMENT FLOORS FOR HAY LOFTS have been found very unsatisfactory on a large Prussian stud-farm. Trouble was experienced with moisture on the floor, in addition to which the stable below required to have a suspended ceiling in order to avoid trouble from drip of condensation. Cement dust getting into the hay also gave rise to trouble.

PERSONALS.

Mr. David Benzie, of Toronto, Ontario, has been appointed City Engineer of St. Catharines, Ont.

Mr. George A. Ricker, M. Am. Soc. C. E., has been appointed Acting Chief Engineer of the Pittsburg, Binghampton & Eastern R. R. with headquarters at Canton, Pa.

Mr. John G. Ullman, Jun. M. Am. Soc. C. E., has been appointed Principal Assistant Engineer of the Pittsburg, Binghamton & Eastern R. R., with headquarters at Canton, Pa.

Mr. Henry M. Steel, formerly Chief Engineer of the Central of Georgia Ry., has become Chief Civil Engineer for J. G. White & Co., Engineers and Contractors, 43 Exchange Pl., New York City.

Mr. John E. Conliff, Civil Engineer for A. Wm. Sperry of New Haven, Conn., has resigned his position to take charge of the construction of a sewerage system for the town of New Canaan, Conn.

Mr. Robert Job, Chemist of the Philadelphia & Reading Ry., has resigned to become a member of the firm of Booth, Garrett & Blair, Analytical and Engineering Chemists, 404-406 Locust St., Philadelphia, Pa.

Mr. Jackson Smith, formerly Manager of the Guayaquil & Quito Ry., has been appointed Manager of Subsistence in the Canal Zone by Mr. John F. Stevens, acting in the capacity of Vice-President of the Panama Railroad.

Mr. John Ericson, formerly City Engineer for Chicago, has been appointed to represent that city in the lowering of the La Salle, Washington and Van Buren tunnels of the street railway company, under the Chicago River.

Mr. Geo. J. Lyon, Professor of Civil Engineering at Colorado College, Colorado Springs, Colo., was married to Miss Mary Colston Coles, of Mamaroneck, N. Y., Wednesday evening, Aug. 1, at Saint Thomas Church, Mamaroneck, N. Y.

Mr. Walter McColloh has been appointed Resident Engineer on the work of improvement of the Canaseraga River in Livingstone County, N. Y. The work is to be done by the N. Y. State Water Supply Commission in order to reclaim about 10,000 acres of valuable land. It will consist of straightening, deepening and improving about 15 miles of the river bed.

Mr. William C. Tucker, M. Am. Soc. C. E., 156 Fifth Ave., New York City, has been appointed Engineer to prepare drainage and water supply system plans for the large office building of the City Investing Co., to be erected on Church and Cortlandt Sts. and Broadway, New York City. The main portion of this building will be 25 stories, with a central tower 5 stories higher. It will have a floor space of 500,000 sq. ft. for offices. Mr. Tucker recently prepared plans of similar nature for the 25-story office building of the Trust Co. of America, Nos. 37, 39 and 41 Wall St. Mr. Francis H. Kimball, 71 Broadway, New York City, is architect for both of these buildings.

Obituary.

Horace W. Bell, District Manager of the Hudson River Telephone Co. at Glens Falls, N. Y., died July 25, of acute locomotor ataxia, aged 44 years.

Col. A. J. Smith, General Passenger Agent of the Lake Shore & Michigan Southern Ry., died July 26, in the Adirondacks, N. Y., aged 60 years. He had been in ill health for a year.

James Richard De Remer died at Denver, Colo., July 26, of paralysis, aged 59 years. Mr. De Remer was the builder of the hanging bridge in the Royal Gorge over which the Denver & Rio Grande R. R. passes. He was born at Mauch Chunk, Pa.

C. A. Bragg, Manager of the Philadelphia Agency of the Westinghouse Electric & Mfg. Co., died at his home in Philadelphia, Pa., July 28, of heart disease. Mr. Bragg was born at St. Louis in 1850, and was a graduate of Yale and a nephew of the Confederate General of the same name. He was an associate member of both the American Society of Mechanical Engineers and the American Institute of Electrical Engineers and had been in the employ of the Westinghouse Co. since 1889.

ENGINEERING SOCIETIES.

COMING MEETINGS.

CONCRETE BLOCK MACHINE MANUFACTURERS' ASSOCIATION.
Aug. 8, 9. Annual meeting at Detroit. Secy., S. L. Wiltse, Jackson, Mich.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Aug. 15 to 17. Annual convention at New Haven, Conn. Secy., Frank P. Foster, Corning, N. Y.

LEAGUE OF AMERICAN MUNICIPALITIES.
Sept. 26 to 28. Annual convention at Chicago, Ill. Secy., Jno. MacVicar, Des Moines, Ia.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Oct. 2 to 5. Annual Meeting at Birmingham, Ala. Secy., G. W. Tillson, Municipal Bldg., Brooklyn, N. Y.

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION.
Oct. 15 to 19. Annual Convention at Columbus, O. Secy., Bernard V. Swenson, 60 Wall St., New York City.

THE RAILWAY SIGNAL ASSOCIATION.—The committee on the subject of "Storage Batteries for Railroad Signaling" has submitted a list of 249 questions to the various railroads, which contain inquiries regarding the proper construction of storage cells, their installation, protection, etc., the manner of charging, the kind of electrolyte used and the question of maintenance.

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION.—The Committee on Standardization has sent out a sheet of questions, to the general managers and engineers of street and interurban railways, regarding the standardization of brake shoes. Besides questions on the size and kind of shoes used, sketches with dimensions of shoe, wheels, etc., are asked for.